

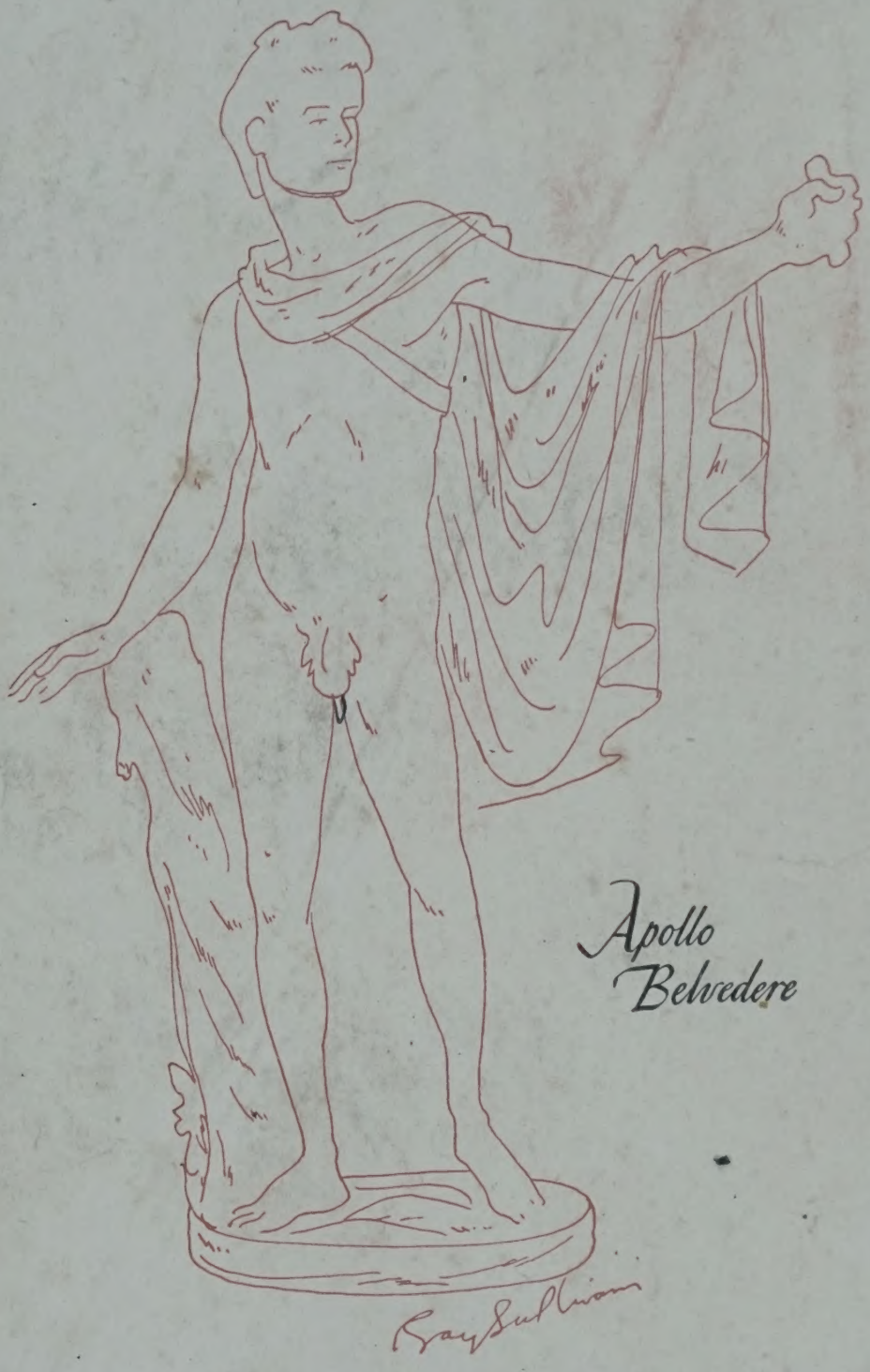
NUTRITION AND PHYSICAL FITNESS

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Nutrition AND PHYSICAL Fitness



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FIFTH EDITION

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Nutrition and

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PREFACE TO FIFTH EDITION

SCIENCE marches on, bringing new knowledge, enlargement and application of previously known facts, new trends in education, and revision of our ideas of the most important factors in nutrition. Although nutritional research during the war years was turned chiefly to practical ends, there have been discoveries of some new vitamins and considerable clarification of the rôles they play in metabolism, while further and more accurate vitamin assays enable us to estimate the probable content of various vitamins in foods within narrower limits. With the knowledge that ten of the amino acids which are combined in proteins must be furnished in adequate amounts in the food for normal growth and health, attention has been focused more on the quality of different proteins according to their amino acid make-up. Food shortages in many lands in the wake of war have made us think in terms of the world food supply, and high food costs have caused us to reevaluate foods in search of those that give best return in several nutritive factors for the price demanded.

These and other developments are reflected in the revision of "Nutrition and Physical Fitness" for the current (fifth) edition. The chapters on Protein-rich Foods and Protein Requirements have been extensively revised, and the need for a certain proportion of proteins of high biological value has been emphasized, especially in the diets for growing children and pregnant women. The chapters on Vitamins have been largely rewritten to include newer discoveries (especially as to B-complex vitamins such as thiamine, niacin, pantothenic acid, biotin and folic acid), free use of chemical names, probable mode of action of various vitamins, requirements and ways of detecting low-grade vitamin deficiencies. The chapters on Mineral Elements have been similarly brought up to date and all tables on mineral and vitamin content of foods have been revised. The latest (1948) recommended Dietary Allowances of the Food and Nutrition Board of the National Research Council have been cited along with discussion of the corresponding nutritive factors in the text, and recapitulated in a table in the Appendix.

The chapters on Food Economics and Recent Trends in American Food Habits have also received major revision. The former includes considerable

discussion of the foods giving the best return in different nutritive factors for relatively low cost, with charts to show the relative cost of calories, protein, calcium, iron, and vitamins A, B_1, and C in different types of food. The latter chapter includes discussion as to how the American diet has been improved nutritionally in recent years by shifts in relative consumption of different classes of food (with charts to illustrate), by enrichment of staple foods with certain minerals and vitamins, by enrichment of the soil, and crop adjustments. There is also a brief discussion of world food problems.

A new chapter has been created for material on Milk and Milk Products other than butter, while the usefulness of fortified margarine as a substitute for butter has been emphasized. New sections have been added in the chapter on Fruits and Vegetables to cover the grouping of these food products recommended by the U. S. Department of Agriculture, the ranking of vegetables in order of their content of five vitamins, and the special importance in the diet of citrus fruits and tomatoes, leafy, green and yellow vegetables. A brief discussion of alcoholic beverages has been included in the chapter on Food Accessories and a table of their caloric values added in the Appendix.

In the section on Diet for Special Conditions, the chief feature is a full revision of the chapter on Diet for Children (from one year on) based on modern ideas of child feeding. Modern viewpoints will also be found reflected in the chapters concerning Diet in Pregnancy and After Forty, and the latter contains discussion of the relation of diet to longevity. Recent surveys as to the prevalence of different degrees of malnutrition will be found in the chapter on that subject.

One of the main features of this edition is the addition of questions, problems, and lists of suggested readings at the end of each chapter. The problems offer practical experience in translating nutritional requirements into foods and menus from the first to the last chapter. The suggested readings are not intended as bibliographies, but consist of a few references to recent books, pamphlets or articles of a less technical nature, which cover different phases of the subject and may be used to supplement discussion in the text, if desired. These features, together with numerous new pictures, charts, and tables (especially the revised and enlarged table of Nutritive Values of Common Foods in Average Servings contained in the Appendix) should add much to the teaching value of the text.

As the science of nutrition has become complicated by increases in the number of nutritive factors known to be essential for health and by demand for more detailed information about the various nutritive essentials, this book has necessarily become more factual with less space available for dis-

cussion of topics of general nature. However, the practical application of nutritional principles in the selection of foods has been stressed throughout, and the chapters on menu-planning, so fundamental for putting nutritional principles into effect, have been retained. Every effort has been made to keep to the clear and readable style that made friends for the book in earlier editions. The design and typography of this edition have been specially planned to make it modern and attractive in appearance. The classical figure used in the design of the cover and title page was selected as a symbol of the beautifully proportioned, well-nourished and healthy human body, which is the objective of good nutrition.

L. JEAN BOGERT

January, 1949

PREFACE TO FIRST EDITION

THE PURPOSE in writing this book has been threefold: (1) To gather into a single volume facts useful in meeting everyday nutritional problems, which have been gleaned from the fields of food composition and economics, the chemistry and physiology of body processes, dietetics, and medicine. (2) To make this information available to a comparatively large group by presenting it in such simple language as to be understandable to those with no previous knowledge of chemistry. (3) To point out, in every instance possible, how such knowledge may be utilized for preventing ill health and promoting a high degree of physical fitness.

With regard to the first mentioned aim, the writer feels that a varied experience in the fields of home economics and nutrition, physiological and medical chemistry, has given her a certain knowledge of subject matter and broader viewpoint of the problems of nutrition, which may be useful in the task of bringing together and correlating many scattered facts pertinent to nutrition. From the subject matter of home economics may be drawn many interesting facts about foods, cookery, and meal planning, which have a distinct influence on nutritional welfare, since they affect the selection of food to make a well-balanced or one-sided ration, the combination of food in meals which stimulate the appetite, promote digestion and tempt one to eat wholesome foods (or in meals which may have the opposite effect in each respect), and finally the preparation of food for the table, in which good or bad cookery may determine its appetizing qualities and digestibility. The technical subject matter of nutrition itself, in the narrower sense, is chiefly concerned with the nutritive requirements of the body, and what quality and quantity of foods must be consumed to make the food supply adequate for all the body needs. Physiological chemistry contributes information as to the processes by which the body utilizes food—digestion, metabolism and excretion. Physiology and medicine have useful advice as to the hygiene of the digestive tract, securing proper elimination, adapting the diet to special conditions of the body, etc. This merely suggests how the different fields of knowledge more or less dove-tail in the special contributions which they make toward a more complete understanding of the

human body, its nutritive processes, and how its needs for food may best be met under varying conditions—*i. e.*, toward an understanding of nutrition in the broader sense.

In endeavoring to make selected facts from such a broad field available to the non-technical individual, the method of presentation has necessarily to be suited to the purpose in view. No subject can be gone into very fully; either the exposition must be confined to special aspects which are important for nutrition or, if the subject is treated as a whole, it must be summarized in as brief a space as possible; the treatment must be suggestive rather than exhaustive. While a certain amount of illustrative material needs to be given in order to make the general argument both more readable and more convincing, it is impossible as a rule to include the experimental evidence which forms the basis for the statements made. Hence statements have to be made more dogmatically than is usually desirable but it should be understood that, while they represent either the consensus of the best current opinion or the author's judgment made after taking into consideration all the evidence available to date, scientific conclusions are always open to revision if new facts are brought to light. In doubtful matters, or where varying circumstances may make different opinions justifiable, we have endeavored to indicate that there are two sides of the case, even though lack of space prevents giving all the conflicting evidence involved in each case.

In selecting subject matter, the aim has been to present the particular facts which anyone needs to know in order to build a sound body and maintain a high degree of health and vigor. Many people, who are not actually sick, are distinctly below par physically—the so-called "80 per centers," although most of them probably have not attained even this high a proportion of the health and vigor which they might enjoy if better nourished. Many children whose development is considered to be limited by heredity, might make better growth and be free from physical defects if their nutritive condition were more favorable. Our present high incidence of physical break-downs at middle age might be greatly reduced if people ate more sanely and moderately in earlier years. Many American diets (those that consist too largely of highly refined, starchy foods, sugar, meat and potatoes) and modern living conditions are unfavorable for promoting good nutrition and health. While not wishing to be an alarmist, one may conservatively say that the conditions which prevail are much in need of improvement. The evidence to show the prevalence of poor nutritive conditions, their significance for health, and suggestions as to how they may be improved will be found in chapters on malnutrition, obesity, constipa-

tion, diet after forty, modern trends in dietary habits, and the influence of factors other than food upon nutrition.

It seems advisable to add a few words to contrast the older mechanistic theory of nutrition with the broader, "physiological" conception which is gradually replacing it. To describe the body as a machine, food as fuel for the engine, certain constituents of the food as repair materials and lubricants, and the ever-interesting vitamins as the ignition spark which is needed to start the engine, may be very well as far as it goes but leaves too much out of the picture. It places too exclusive emphasis upon the food intake, and takes too little into account the body functions necessary to the utilization of that food, and the many complex variables which affect these functions. The influence upon nutrition of body structure, of good or poor functioning of the various organs and tissues, of interrelations between the different parts of the body and between the body and external conditions, of habits of living and mental states, all need to be recognized. In short, the body should be thought of, not as a machine, but as a complex, interacting, living organism, whose satisfactory cooperation in the task of maintaining good nutrition is of equal (but not greater) importance to health as is a food supply adequate to meet body needs. This complicates the problem but we think most of our readers will join with us in attesting the truth of the old maxim of Dr. Rabelais, "And if you desire to live in peace, joy, health, making yourself always merry, never trust those men that always peep out at one hole."

L. JEAN BOGERT

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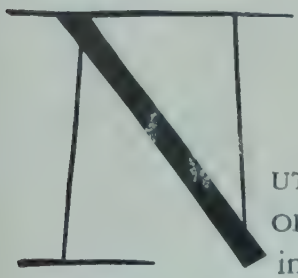
PART

1

FOODS

CHAPTER 1

CONCERNING FOODS AND FOODSTUFFS



UTRITION may be defined very simply as the SCIENCE OF NOURISHING THE BODY PROPERLY—that is, providing adequately for its growth, maintenance and repair. The wants of the body are met by its intake of FOOD. Although it should be emphasized that food is not the only factor to be taken account of in nutrition, it is probably the most important single factor. Speaking generally, we may say that there are TWO main factors in nutrition—FOOD AND WHAT THE BODY DOES WITH IT. A number of different factors combine to determine the body's ability to utilize its food, while the food itself is the raw material for body processes. In a way it is difficult to say that any one factor is more important than the others because good nutrition cannot be obtained unless all are working in harmony. However, it is certainly obvious that we cannot expect to maintain the body in health without supplying it with the raw material necessary to provide for growth and to repair the losses which it suffers by the wear and tear of life. This raw material is furnished in the diet, and hence the importance of selecting the food with care to supply ALL the body needs.

Food consists of those substances which furnish energy to the body, build tissue, or regulate body processes.

An individual food may fulfill all three of these functions or only one, but all three must be provided for by the diet as a whole to maintain the body in health. Most foods can fulfill more than one function because they are mixtures of a number of different chemical substances.

Chemical Composition of Matter. Everything we see and touch is some form of matter. In fact, even invisible gases like air are matter in a dilute state, for matter is defined as anything which occupies space and has weight. Different kinds of matter—such as oxygen, iron, water, sand, sugar, or olive oil—are called **substances,** and every substance has definite characteristic qualities and composition by which it can be recognized and identified.

Chemically speaking, there are two great classes of matter—**elements** and **compounds.** The elements are the simplest forms of matter, the pri-

mary building stones from which all other substances are made. Oxygen and iron are two of the ninety-two naturally occurring elements. This large number of elements may be combined in various combinations and proportions to give an infinite number of more complex substances called compounds. Water, sand, sugar, and olive oil are compounds. The chemist conceives of elements as made up of minute, invisible particles called **atoms,** and compounds as consisting of similar tiny particles known as **molecules.** All the atoms in an element are chemically alike, and the molecules of a compound are likewise uniform in their attributes and composition. Hence all specimens of any given substance possess the same properties and composition. In other words, pure iron is always the same throughout and, wherever it is found, easily recognizable by its color, density, chemical composition and reactions with other substances.

Matter may also be classified as to whether it is **inorganic** or **organic.** Of the substances mentioned in the above paragraph, air, oxygen, iron, sand and water are inorganic, while sugar and olive oil are examples of organic compounds. If you heat an organic substance, it will char and, on further heating, will burn leaving little or no residue. Most of the compounds found in plants and animals—or in materials which were once living, *e. g.*, wood, coal, a candle—contain the element carbon, as becomes evident when they char on heating. Hence the term "organic" is now used to designate the compounds of carbon, whether formed in living organisms or made in the laboratory. Hundreds of thousands of organic compounds are known to exist, and our foods are for the most part made up of this class of compounds.

Chemical Composition of Foods. The organic or combustible portion of foods, which comprises much the greater part of their solid matter, falls mainly into three great classes of substances—the **carbohydrates, fats,** and **proteins.**

All the sugars and starches found in our food belong to the group called **carbohydrates**—substances made up of the elements carbon, hydrogen, and oxygen.[1] Ordinary granulated sugar and corn starch are examples of carbohydrates separated in purified form.

Fats are another kind of compound made of carbon, hydrogen and oxygen, but with these elements present in different relative amounts than in carbohydrates. They constitute the greasy substances familiar in fairly pure form in butter, salad oils, lard and meat fats.

Proteins also contain carbon, hydrogen and oxygen (again in different

[1] The hydrogen and oxygen are present in the same two to one proportion in which they are found in water, hence the name, carbohydrate. Of course this does not mean that water is present in the carbohydrates.

proportions), and in addition they always contain some of the elements nitrogen and sulfur. They are substances of "gluey" consistency, which are found in eggs, the muscle fiber of meat, the curd of milk or cheese, and the gluten of flour or bread. Egg white is the best example of protein in pure form. It is characteristic of proteins that they are precipitated or "coagulate" on heating.

Cellulose and hemicelluloses are relatively indigestible carbohydrates which are present in the walls of plant cells. They make up the fibrous material in cereals, vegetables and fruits. Since they cannot be assimilated by the human body, they are of little or no importance as food, but are useful in giving sufficient bulk to the intestinal residues to prevent constipation. They are often referred to as vegetable fiber, ballast, or roughage.

Vitamins are organic substances, different from any of those described above, which are present in small but varying amounts in foods. They play an important part in nutrition, since they are required for normal growth and for the maintenance of life in both plants and animals, including man. Their distribution in foods and their functions in the body have been extensively studied, and the chemical composition of most of them is now known. The vitamins differ widely in their chemical nature, rather than belonging to any special group of similar compounds as the proteins, fats and carbohydrates do.

The list of vitamins has been growing with recent discoveries, but it is not known that all of them are essential for human beings. Those best known as needed by man are called:

Vitamin A
" B_1 or thiamine
" B_2 or riboflavin
" C or ascorbic acid
" D
" K
Niacin or nicotinic acid

Mineral salts constitute the inorganic or noncombustible portion of our foods, *i. e.*, they form the ash which is left behind on burning and hence are often spoken of as the ASH CONSTITUENTS. These salts are made up chiefly of the following chemical elements in varying forms and combinations:

Base-forming elements.	Acid-forming elements.
Sodium	Chlorine
Potassium	Sulfur
Calcium	Phosphorus
Magnesium	Carbon
Iron	

The base-forming and acid-forming elements are combined in neutral compounds called SALTS. Certain of these salts exist preformed in foods, while others are formed in the process of burning and were present in the food originally in other combinations. Traces of other mineral elements are also found in foods, some of which (*e. g.*, iodine) are important for health.

Water is present in nearly all foods. That it often forms a large part of foods can be seen from their striking shrinkage and loss of weight on drying. Fruits and juicy vegetables like tomatoes may contain eight or nine parts by weight of water to one or two parts of solids. Even such an apparently "dry" food as crackers has a water content of 5 to 6 per cent. Only such foods as pure fats (lard, salad oils) and refined (granulated) sugar contain practically no water.

Essential Nutrients or Foodstuffs. There are thus six kinds of substances provided in foods, which are necessary to the body:

Carbohydrates	Vitamins
Fats	Mineral elements
Proteins	Water

These are often spoken of as **foodstuffs.** The first three are usually called **fuel** (or organic) **foodstuffs,** since they are the only substances which the body can burn or use as fuel to supply energy for work and heat. The mineral elements and water are sometimes called **inorganic foodstuffs.**

It is worth while to consider which of the above classes of nutrients may be depended upon to meet the body needs for (1) energy, (2) building materials, and (3) body regulators.

Food Substances Which Yield Energy. Digestible CARBOHYDRATES (starch and sugars) furnish a large proportion of the energy required to maintain the body at normal temperature and to do its daily work (internal and external). FATS also form a concentrated source of body fuel, and whenever the supply of carbohydrate and fat is insufficient for the energy needs of the body, PROTEINS can and will be burned as fuel. These combustible organic substances must be burned up or oxidized in the tissues, in order that the energy stored in them be set free and hence be available for body use. Since mineral salts and water cannot be further oxidized, they are incapable of supplying energy to the body. Vitamins also serve other purposes but are not burned as fuel.

The exact balance between the three fuel foodstuffs in the diet is not very important, as they can be used more or less interchangeably for fuel according to which are supplied in greater abundance. However, there are

various reasons (to be taken up later) which make it seem probable that, in the long run, the best interests of health will be served by a diet which furnishes about 50–60 per cent of the energy from carbohydrates, 25–35 per cent from fats, and 10–15 per cent from proteins.

Most foods consist chiefly of these three foodstuffs, with some one of them predominating. Thus grains have a high content of carbohydrate in the form of starch, lean meats are richest in protein, while fatty meats contain less protein and a higher proportion of fat. Because indigestible carbohydrates (like cellulose), inorganic salts and water furnish no energy, foods with high content of these substances will be low in fuel value, and vice versa.

Food Substances Which Build Tissue. PROTEINS, MINERAL ELEMENTS, and WATER all enter into the composition of body tissues. Proteins are needed especially for building muscle tissue, mineral elements such as calcium and phosphorus for bones, iron for the blood, and water is an important part of almost all tissues. Hence all these substances are essential for the up-keep of the tissues and are needed in extra amounts whenever growth is going on. Vitamins are also necessary for growth and some of them may be built into or stored in the tissues. Fats may also be stored in fatty tissues.

Substances Which Regulate Body Processes. WATER is an important regulating substance in the body. It serves to hold other substances in solution in the digestive juices, blood and tissues; it aids in excretion, circulation, and many other body processes. MINERAL SALTS and VITAMINS help promote oxidative processes, normal functioning of nerves and muscles, vitality of tissues, and are of assistance in other bodily functions too numerous to mention here. Vegetable fiber (cellulose) acts to promote intestinal elimination.

How Composition of Foods Is Studied. What nutrients, and how much of each, are present in our various everyday foods is usually determined either

(1) by chemical analysis, or
(2) by biological assay.

Chemical analysis provides useful data as to the approximate distribution of the foodstuffs in any given food between carbohydrates, fats, proteins, mineral matter and water. It also enables us to determine with fair accuracy the amounts of such mineral elements as iron, calcium, phosphorus, sulfur, sodium, chlorine, etc., present in different foods. Methods commonly used for determining the relative amounts of the foodstuffs, other than vitamins, are briefly outlined below.

WATER is determined by weighing a sample of the food before and after drying to constant weight.

ASH (mineral matter) is ascertained by completely burning the combustible portion and weighing the noncombustible residue.

PROTEIN is computed by multiplying the nitrogen content (chemically determined) by 6.25, since proteins are known to consist of about 16 per cent (one-sixth) nitrogen by weight. Slight errors are involved both by including as proteins any other nitrogen-containing substances present in the food, and by reason of the fact that proteins vary somewhat in the amount of nitrogen they contain.

FATS are determined by extracting a dried sample of the food with ether. With the true fats (weighed after evaporating to dryness the ether extract) will be included small amounts of other ether-soluble substances such as resins, waxes, and coloring matter (pigments).

CARBOHYDRATES are usually determined by difference, that is, the remainder of the weight not accounted for under one of the above heads is assumed to be carbohydrate in nature and is listed as such. While the bulk of this residue undoubtedly does consist of carbohydrates, it will also include organic acids (in fruits and vegetables), indigestible carbohydrates (cellulose and hemicelluloses) which have no food value, and various other undetermined substances not carbohydrates.

In some cases, the crude FIBER is determined separately, subtracted from the total carbohydrates, and the remainder listed as UTILIZABLE CARBOHYDRATES. More accurate figures may be obtained by direct analyses for determining the carbohydrates through their reducing powers.

Tables of food composition, obtained by the above methods, can never be absolutely accurate for several reasons. First, certain errors are inherent in the methods used or in the manner of calculating results (as pointed out in describing the methods above). Then, even in the hands of skilled chemists, small errors occur which are magnified on calculating the composition from the basis of a small sample to a percentage basis for the food as a whole. Lastly, and probably of most importance, foods may vary considerably in composition either in samples from different sections of the country, in different parts of the same sample, or especially in cooked foods where moisture and fat content are frequently variable. When a large number of samples of some raw food material like flour, milk, or eggs, have been analyzed, AVERAGE values are obtained from which individual specimens probably will not differ much in composition. With cooked foods, fruits and vegetables, or whenever only a few samples have been analyzed, variations will be larger and figures less accurate.

Biological assay of foods is often used to determine their vitamin content. By this we mean actual feeding experiments on laboratory animals (usually rats, guinea-pigs, or chickens) under controlled conditions. White rats, whose heredity and previous diet history is known, are considered the best "standardized" animals, and hence apt to give the most accurate results. Moreover, the chemistry of their body tissues is, for the most part, similar to that of man, and their life cycle is short enough so that one can

watch the effects of some special diet on several generations. Such animals are fed a simple diet of known composition, which is planned so as to provide plenty of all the essential nutrients EXCEPT ONE. A certain food is added to this basal diet in known amounts to serve as the sole source of the nutrient in which it is lacking and for which the special food is being tested.

By such experiments, the existence in natural articles of food of VITAMINS has been established. Likewise it has been discovered that numerous different vitamins are necessary in the diet for the well-being of man, and the relative amounts of each vitamin supplied by different foods has been more or less accurately determined. Laboratory feeding experiments also give information, not obtainable by chemical analyses, as to how EFFICIENT the PROTEIN content of different foods is for growth or maintaining weight, and how well ASSIMILATED and utilized the MINERAL content of certain foods may be. Thus biological assay shows us how effective different foods really are in supplying the needs of the body for proteins, minerals, and vitamins.

Some of the vitamins may now be determined by **physical** methods (measurement of absorption spectra, fluorescence, etc.) or by **chemical** methods (chiefly by color reactions). However, feeding tests with animals retain their usefulness and in many cases are indispensable.

Food Groups. The simplest and most convenient way to study the different common foods is to GROUP THEM IN SEVERAL LARGE CLASSES. The foods grouped together are similar in chemical make-up and fulfill the same general functions in the diet. Hence, if we learn to think of various foods in connection with the group with which they belong, we can easily substitute one food for another similar to it, avoid eating too many foods of the same class, and see that no one group is poorly represented in the diet. For these reasons it is very important to learn to associate the similar foods in their proper classes. The different CLASSES OF FOODS may be listed as follows:

(1) **Sugars and starchy foods** (bread, flour, other cereal products).
(2) **Fatty foods** (butter, margarine, lard, salad oils).
(3) **Protein-rich foods** (meat, poultry, fish, eggs, legumes, nuts).
(4) **Milk and milk products** (other than butter).
(5) **Fruits and vegetables.**

Because fruits and vegetables vary more widely as to composition, especially as to vitamin content, the U. S. Bureau of Human Nutrition and Home Economics prefers to subdivide them into three groups:

(a) Green and yellow vegetables (yellow fruits).
(b) Citrus fruits (oranges, grapefruit), tomatoes, etc.
(c) Potatoes, and other vegetables and fruits.

This arrangement, together with the first four classes listed above, furnish the SEVEN BASIC FOOD GROUPS suggested by government agencies during the war years. Their advice is that some food (or foods) from each of these seven food groups should be included in the diet daily.

Some authorities group separately sugar and sweets, potatoes and sweet potatoes, and mature legumes (peas, beans) and nuts, thus making ten or more food groups. For our purposes, it is more convenient and sufficiently accurate to consider foods grouped as to whether their main contribution in the diet is carbohydrate or fat (fuel), protein, minerals or vitamins.

QUESTIONS AND PROBLEMS

1. What are the three uses of foods in the body? Name the six kinds of essential nutrients found in foods. Which of these can serve as body fuel and why? Which are used in the building and repair of tissues? Which are necessary to regulate body processes?

2. What happens when sugar is heated to a high temperature? Contrast this with results of heating salt. (Suggest teacher give a demonstration of this, holding beaker or other cold object over burning sugar to show that water is given off.) Explain the difference or differences between organic and inorganic substances. Which of the six essential nutrients are organic and which are inorganic substances?

3. Compare some sugar, cornstarch, egg white, and lard (samples displayed). Describe the characteristics by which you could recognize each or distinguish one from the others. Define carbohydrates, proteins, and fats. Do they usually occur in pure form or mixed together in foods?

4. On page 11 is listed the gross composition of ten common foods, in percentages or parts of each constituent per 100 parts of food. Select from this list foods that are richest in carbohydrate, in fat, and in protein. From which classes of food do we get most of our fiber, mineral elements, and vitamins?

5. Name the five main classes of foods suggested in the preceding chapter as characteristic of their main contributions in the diet. Name the seven basic food groups suggested by the U. S. Dept. of Agriculture. From the ten foods listed in the table above, select one to represent EACH of the seven basic food groups and plan a meal that will include these seven foods.

6. Explain what is meant by the biological assay of foods. What infor-

mation can be obtained by biological assay and how does it supplement facts obtained by chemical analysis? Describe how a food may be assayed for its content of a certain vitamin.

PERCENTAGE COMPOSITION OF FOODS

	Water.	Protein.	Fat.	Carbo-hydrate.	Ash.	Fiber.
Bread	35.9	8.5	2.0	52.3	1.3	0.3
Butter	15.5	0.6	81.0	0.4	Ash consists of salt added.	
Sugar	0.5			99.5		
Egg, whole	74.0	12.8	11.5	0.7	1.0	
Beef, lean round	67.0	19.3	13.0		0.9	
Beans, lima	66.5	7.5	0.8	23.5	1.7	1.5
Potato, white	77.8	2.0	0.1	19.1	1.0	0.4
Carrots	88.2	1.2	0.3	9.3	1.0	1.1
Oranges	87.2	0.9	0.2	11.2	0.5	0.6
Milk	87.0	3.5	3.9	4.9	0.7	

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CHAPTER 2

SUGARS AND STARCHY FOODS

ALL THE important food CARBOHYDRATES are either SUGARS or STARCHES. In fact, the starches are made up of many sugar groups linked together and, when digested, the bonds that hold them together are severed and they fall apart into the simple sugars again. Thus all carbohydrates are either sugars or compounds made by the union of sugar groups (starches), and this is the reason why sugars and starches are practically the same thing after they are digested and taken into the body tissues. All of the food carbohydrates except milk sugar are formed in the vegetable kingdom.

Kinds of Carbohydrates and Their Occurrence. Most people think there is only one sugar, that is, ordinary table sugar, but there are really five SUGARS which are found in considerable amounts in our foods. Our white granulated sugar usually comes from the sap of the sugar cane, so that it is frequently called cane-sugar. Of late years, however, about one-third to one-half of the sugar on the market has been made from the juices of the sugar beet. The real chemical name of this sugar is **sucrose.**[1] Sucrose together with two simpler sugars called **glucose** and **fructose** are found (usually mixed together) widely distributed in the sap of different plants and in the juices of all the fruits. Because the sugars are very soluble in water, they are the form in which plants transport carbohydrate from one part to another in the sap or tuck it away for temporary use in the fruit. For more permanent storage in the seeds, roots, or tubers, the plant makes the sugars over into the more complex compound, starch, which is not soluble in water.

The other two sugars are those found in milk (milk-sugar or **lactose**), and in malted or sprouting grains (**maltose** or malt-sugar). The latter sugar is an intermediate product of the breaking down of starch and is present in considerable amounts in such artificial products made from partly digested starch as corn sirups, dextri-maltose, malt breakfast cereals and malted milks.

[1] Cane-sugar, beet-sugar and maple-sugar (made from the sap of the sugar maple) are all sucrose.

As stated above, **starch** is found in the seeds, tubers and roots of plants. The starch found in different plants is all chemically the same but is tucked away in little bundles or packages covered with a wrapping or membrane of a very insoluble material called cellulose (the same material which makes up the woody fiber of the plant). These are called starch grains or granules, and each plant has a characteristic size and form of granules, so that we can easily tell wheat starch from potato starch when we look at the starch grains under a microscope (see Fig. 1). Starch is also present in unripe

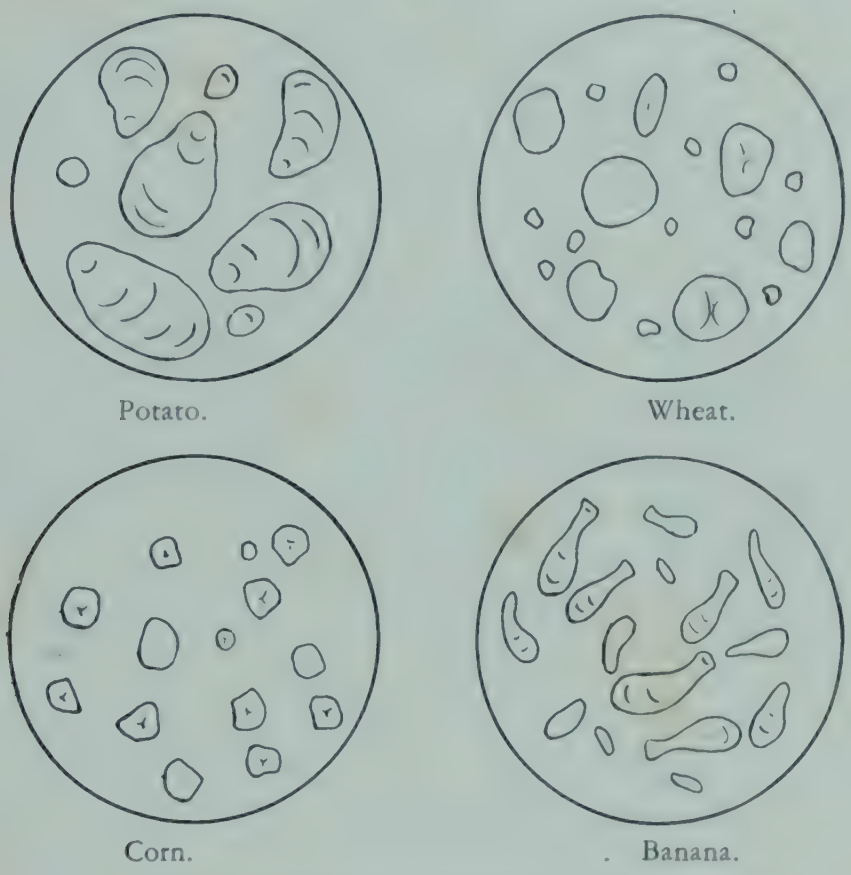


Fig. 1. Typical forms of starch granules in different plants.

fruits and turns to sugar as the fruits ripen (Fig. 11, p. 87). Bananas are often eaten before they are completely ripe. Considerable amounts of starch exist in this fruit when it is clear yellow or green-tipped, which have been almost entirely converted to sugar at the fully ripe stage (yellow skin liberally flecked with brown). In unripe seeds and grain, however, some sugar is present which gradually is converted to starch as the seed matures. This accounts for the sweet taste of green corn and peas.

In cooking, the covering of the starch granules is ruptured and the starch itself is slightly changed chemically by the heat and moisture, so

that it is more soluble. Both of these changes make cooked starch more readily and quickly digested than raw starch (see Fig. 2), although the latter may ultimately be fairly well digested. Starchy foods that contain much fiber, such as whole grain products and starchy vegetables need longer cooking to soften the fiber as well as to cook the starch.

We have said that our FOOD carbohydrates come practically entirely from the vegetable kingdom. Animals use carbohydrate for their hand-to-mouth fuel supply or source of energy, just as plants do, but they have almost no ability to store carbohydrate, hence we find very little of it present in our animal foods. The sugar **glucose** is always present in blood, the circulating fluid of animals analogous to plant sap. This is one of the simplest sugars and NO OTHER SUGAR IS EVER FOUND IN BLOOD OR TISSUE FLUIDS. In the liver, and to a lesser extent in the muscles, animals can store a very limited amount of a more complex carbohydrate called **glycogen** or "animal

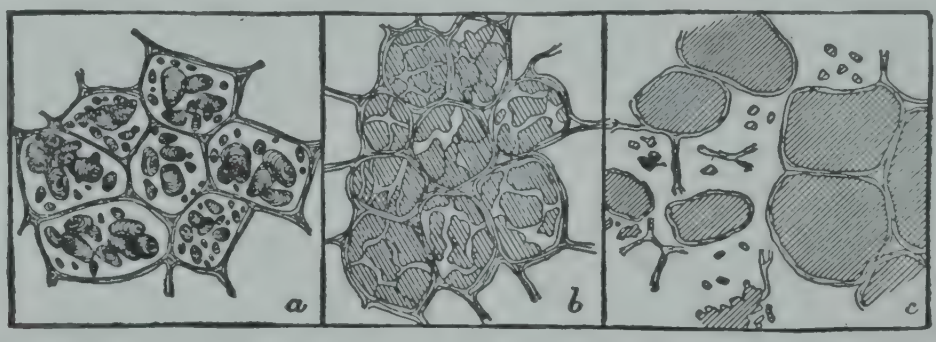


Fig. 2. The potato—changes in starch granules and cell walls produced by cooking. *a*, raw; *b*, cooked; *c*, thoroughly cooked. (U. S. Department of Agriculture.)

starch." A sugar, milk-sugar or **lactose,** is contained in the milk secreted by mammals for the nourishment of their young, and this is the only carbohydrate of animal origin which enters largely into our food supply.

Carbohydrate-rich Foods. The most important of these, together with the approximate amount of carbohydrate each contains, are listed in Table I (p. 15). Their carbohydrate content ranges from about 15 to 100 per cent. Thus it will be apparent that, though these foods are relatively **rich** in either sugars or starch, in their natural state they contain numerous other substances besides carbohydrates. A few highly refined articles, artificially prepared foods such as refined sugar, corn starch, etc., are pure carbohydrate (with traces of moisture), but even food products as nearly pure starch as highly milled rice and wheat (patent flour) carry with them considerable amounts of protein (7.5–11 per cent), while dry beans and peas contain over 20 per cent of protein along with approximately 60 per cent of starch. Soybeans differ from other legumes in that they contain less starch

TABLE I. FOODS RICH IN CARBOHYDRATES

Rich in sugar.	Carbohydrates.	Rich in starch.	Carbohydrates.
	per cent		*per cent*
Sugar:		Starches:	
White, granulated	99.5	Corn or arrowroot	87
Brown	95.5	Tapioca, dry	86
Maple	90	Flours:	
Corn (dextrose)	90	Barley	77
Sirup:		Rye, medium	76
Corn	74	Wheat, white, patent, avg.	76
Maple	64	Entire wheat or Graham	72
Molasses, medium	60	Rice, white, dry	79
Candy	60–95	Boiled	23
Honey	79 5	Oatmeal, dry	68
Jams and preserves	71	Cooked	11
Jellies	65	Cornmeal, bolted, dry	78
Dates, dried, edible portion	75	Cooked	12
Raisins, seeded and seedless	71	Wheat breakfast cereals:	
Prunes, dried	71	Dry	75–79
Figs, dried	68	Cooked, about	12
Apricots, dried	67	Macaroni, spaghetti and noodles (wheat pastes):	
Chocolate, sweetened	60	Dry	71–75
Fresh fruits, edible portion:		Cooked about	19
Bananas		Beans (except soy) or peas, dried	60–62
Cherries, sweet		Breads:	
Figs	15–23	Corn	46
Grapes		Rye	52
Pomegranates		Wheat, white, avg.	52
		Graham or whole wheat	48
		Toasted	62
		Rolls	50–60
		Crackers, average	73
		Cakes, plain	57
		Frosted	60–70
		Cookies	70–75
		Macaroons	65
		Pies	22–50
		Cereal puddings	27–31
		Potatoes, sweet	28
		White	19
		Beans, lima, green	23
		Beans, canned or cooked	
		Corn, sweet, fresh or canned	16–20
		Succotash	
		Peas, green, fresh	18
		Canned	13

and more protein and fat. The legumes and grains also contain some indigestible fiber, minerals, and vitamins.

Potatoes, on the other hand, though included among the starchy vegetables in Table I because most of their food value is due to starch, are such a watery food that they really contain only about 19 per cent starch along with 2 per cent protein and 78 per cent water. Sweet potatoes have a higher carbohydrate content (28 per cent), with both starch and sugar present.

Milk, which is a very dilute food (87 per cent water) and is usually classed with the protein foods because it is such a valuable source of protein, nevertheless contains more than one-third of its solid material in the form of the carbohydrate milk-sugar. Milk also contains fat, mineral salts and vitamins. In fact, most of our foods contain some of all six of the essential nutrients or foodstuffs (see p. 6), and are merely classified under the head of that one in which they are especially rich or of which they form a valuable source of supply. It must always be remembered that foods are MIXTURES of many different substances, but this does not prevent the practice of grouping them together as to their richest constituent from being very helpful.

Summary. Foods RICH IN STARCH are all the cereal grains (wheat, corn, rye, barley, oats, and rice) together with all flours, breakfast foods, breadstuffs, macaroni, cakes, pastries and puddings made from these cereals; the purified starch preparations such as corn starch, arrowroot starch, tapioca and sago.

Foods MODERATELY HIGH IN STARCH content are the legumes and certain tuber and root vegetables.

Foods RICH IN SUGAR are the purified sugars, honey, molasses and sirups, candies, jams, jellies, marmalades, preserves and dried fruits. Stewed and canned fruits usually have variable amounts of sugar added in cooking.

Many fresh fruits and a few vegetables (see list on p. 24) contain carbohydrate in lesser but appreciable quantities, chiefly in the form of sugar.

We might condense the above still further and state it with approximate accuracy as follows:

Carbohydrate-rich foods	Cereal grains and their products
	Sugar, candies and sirups
	Many fruits, especially when dried
	Some vegetables, especially legumes and potatoes

INTERESTING FACTS ABOUT CARBOHYDRATE-RICH FOODS

Grains. The cereal grains are seeds of the grasses. From the time of the beginnings of agriculture they have been the chief reliance of all peoples for their food supply. They are easily cultivated and stored, and can be

brought by relatively simple processes into the form of palatable, wholesome and economical food. They are usually crushed into a fine meal or flour, and made into bread, which is leavened by yeast. Bread has thus been for centuries literally "the staff of life" of many nations, especially those of Europe and America.

As civilization has advanced and a larger variety of foods has become available, bread has lost some of its major importance. It is still regarded as a staple article of diet by all classes, however, and the poorer classes eat it in surprisingly large amounts even when they can get equally nourishing foods at the same cost, both from preference and because of its "filling" qualities. With the more prosperous peoples, meat tends to take a prominent place in the diet, while potatoes have in recent years to some extent supplemented bread as an economical starchy food. In the United States, the per capita consumption of bread has decreased in recent years, but the use of a great variety of breakfast cereals has kept the total consumption of wheat and other grains from falling off to any great extent.

The principal grains are RICE, WHEAT, RYE, BARLEY, OATS and CORN. Their differences are chiefly as to where grown and extent used, but their striking similarities as to composition (see table on p. 20) and food functions (p. 25) are more worthy of emphasis than these minor differences.

Rice is grown chiefly in moist tropical or semitropical climates, and has the largest consumption of any of the grains due to its very important place in the diet of the populous eastern countries. Not only is it the chief food for about half the human race, but in the oriental countries it forms a larger proportion of the diet than wheat, rye, barley and potatoes combined do in the food of western nations. It is eaten both in the brown state (cured rice) when only the outer husk has been removed, and as white (polished) rice from which the outer coats of the grain have been removed in milling. By far the larger amount is consumed in the highly milled condition (white rice).

The nutritive condition of rice-eating peoples might be much improved if a recently developed process of "converting" rice became common practice. By this process rice is treated so that much of its vitamin B_1 content is transferred from the outer layers to the internal part of the kernels which can then be "polished" with much less loss of this important vitamin.

Wheat comes next in total amount produced and consumed, largely due to the fact that it is the preferred grain for making yeast breads because its higher gluten (protein) content lends a toughness and elasticity to the dough, which makes possible a larger lighter loaf of bread. It is extensively raised in the western United States and Canada, South America, and Russia.

Wheat flour is also used, especially in Italy, for making such pastes as macaroni and spaghetti.

Rye approaches wheat in bread-making qualities more nearly than any other grain. It is grown in some northern sections where wheat does not grow well and rye bread is commonly used in Germany and Scandinavian countries. Rye could be more widely grown, if desired.

Barley is also grown where wheat does not thrive, that is, in the more arid regions, and it is the bread-making grain in such localities. It is used in the United States chiefly in the form of pearled barley in soup and as patent barley flour for infant feeding.

Oats do not make a good bread but are extensively used in Scotland and Sweden as oat cakes (eaten by both men and animals), and as porridge. More recently the use of oats as a breakfast cereal has been extended to England and the United States, and their increased consumption should be encouraged because their general nutritive qualities after milling are greater than those of any other grain, as will be pointed out under their composition later on (p. 20, footnote 3, p. 21). Oatmeal (mixed with other flour) may also be used in muffins, cookies, and crackers.

Corn in amount produced is the chief grain product of the United States, but most of it is used for feeding animals. Only 10 to 15 per cent of our corn crop is utilized for human consumption, and much of this is used in the manufacture of corn syrup (glucose) and corn starch rather than consumed direct as hominy or cornmeal. The feeding of any grain edible by man to animals is economically wasteful, since it has been shown that the animal is such an inefficient transformer of the energy of the food fed into food available for man that as much as 40–85 per cent of the energy of the grain fed may be lost. Our corn crop, therefore, represents a vast reservoir of food which would be available for human use in time of stress. Although corn does not form an elastic dough which can be leavened by yeast, it makes acceptable bread, muffins, griddle cakes and puddings, besides its uses as mush, hominy and hominy grits.

In order to be prepared for human food, all of the grains have to be subjected to the process of **milling.** Not only must the husk be removed, but some of the tough outer coats of the grain (BRAN) must be rubbed or scoured off, and the oily embryo (GERM) located at one end of the seed (see Fig. 3) is also usually removed in some way. The grain would not be very digestible if the coarsest bran coatings were not removed, and the germ is removed to keep flour from spoiling when it has to be stored for a long time. Nevertheless these outer parts of the seed contain much valuable nutriment, and when they are completely removed by extensive milling the

process is wasteful and a one-sided, artificial food is the result. Much of the protein and mineral salts are situated in or near the outer coats of the grain; practically all of the fat and much of the vitamins are located in the germ (see diagram of distribution of nutrients in wheat grain, Fig. 3). The important vitamin B_1 or thiamine is concentrated chiefly in the scutellum, a thin layer of powdery material that constitutes the outer part of the germ. Hence the highly milled grain products, which represent only the inner part of the kernel, consist chiefly of starch mixed with a small amount of protein material. The protein is never completely removed by milling, as there

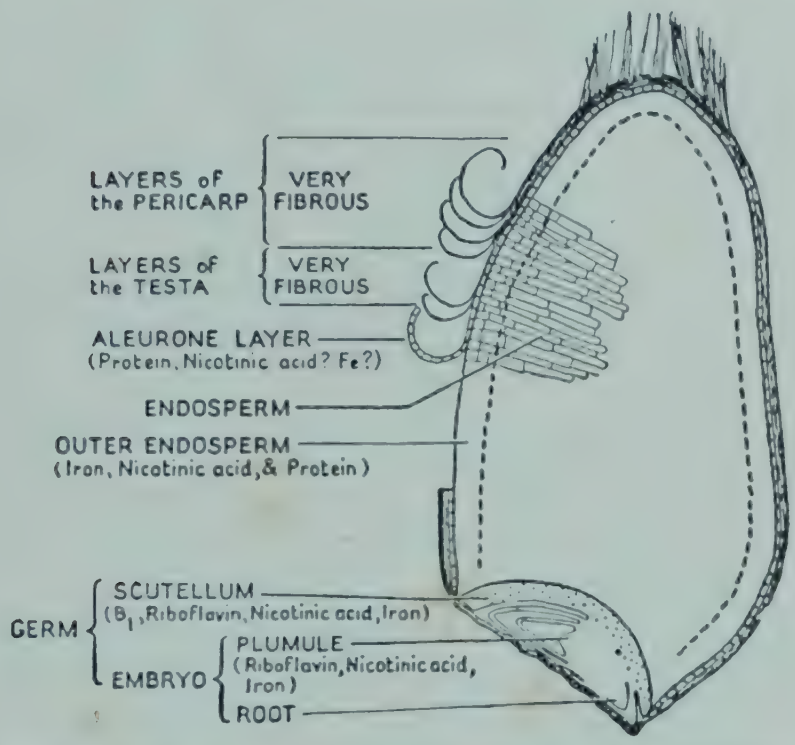


Fig. 3. The distribution of nutrients in the wheat grain. (Sir J. Drummond and Dr. T. Moran. By courtesy of The Lancet.)

is some throughout the inner part of the kernel (endosperm). However, the amount of protein, mineral salts, fat and vitamins found in any grain product is an index of the extent to which the germ and outer layers have been removed in milling.

It remains to be pointed out that all the grains are VERY SIMILAR IN COMPOSITION, which is of course why they fill the same place in the diet and are almost interchangeable in their uses. In Table II we have listed what are probably the most commonly used products of each of the grains, side by side for comparison. Of the products listed only the "whole wheat" flour and oatmeal have NOT been highly milled. It should be noted that these

two products show the higher protein, fat and ash (mineral salts) characteristic of products where the germ and bran have not been removed by milling. Both of them represent practically the whole grain except the husk. "Patent" wheat flour represents a product where practically ALL of the outer coats of the wheat have been removed in the milling. The term "whole wheat" flour is now used as practically synonymous with graham flour, even though part of the bran may be removed in its manufacture and it may be somewhat more finely ground than the latter.

TABLE II. COMPOSITION OF SOME COMMON PRODUCTS OF DIFFERENT GRAINS*

	Polished rice.	Wheat.		Rye flour (light).	Pearled barley.	Corn meal (white).	Oatmeal.
		Patent flour.	Whole wheat flour.				
	per cent	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*
Carbohydrate	79.4	75.9	72.4	78.5	78.8	78.8	68.2
Protein	7.6	10.8	13.0	8.9	8.2	7.5	14.2
Fat	.3	.9	2.0	.9	1.0	1.1	7.4
Ash	.1	.4	1.6	.7	.9	.6	1.9
Moisture	12.3	12.0	11.0	11.0	11.1	12.0	8.3

* Figures from U. S. Dept. Agriculture, Tables of Food Composition, 1945.

The chief **value of using whole grain products** lies in their higher content of vitamins, mineral salts and fiber, rather than in any special difference in protein or energy value. It should be remembered that even the whole grains are deficient in certain of the minerals and vitamins, so that they need to be supplemented with other foods, especially milk, vegetables and fruits. Nevertheless, one is justified in emphasizing that the use of whole grain products does give a very desirable factor of safety as to those elements (vitamins and ash constituents) in which our diet is apt to be low, while the loss of valuable food materials through the over-milling of our grains is an uneconomical procedure.[2]

"**Enriched**" flour and bread, which have been recently sponsored by U. S. government authorities, are intermediate in nutritional value between

[2] Only about 72 per cent of the wheat grain is recovered for human food by the process of manufacturing patent (white) flour. The by-products, which contain much of the protein and iron and $\frac{9}{10}$ of the vitamin B_1, are used for animal feed. As a war-time measure, Great Britain used 85 per cent of the wheat kernel in flour, which retained almost all of the minerals and vitamins and made bread that was well digested and only slightly less white and porous than the usual "white" bread.

vitamin and mineral-impoverished highly milled products and whole grain products. Patent white flour is enriched by the addition of synthetic vitamins—thiamine, riboflavin and niacin—and iron, almost but not quite up to the level in average whole grain flours. It should be remembered that whole grain flours contain other B-complex vitamins and minerals not added in enrichment of white flour, and also that their protein content is of higher quality (more efficient in promoting growth) than that of white flour. However, for those who prefer white bread, its enrichment with certain vitamins and iron makes considerable improvement in the nutritive value of a staple food.

Summary. By glancing at each column in Table II (p. 20) from left to right, you will note the following important facts to be true of the cereal grain products listed:

(a) All consist chiefly of carbohydrate (starch).
(b) All contain some protein, but whole wheat flour and oatmeal are richer in protein than others.
(c) All are relatively low in fat[3] and in ash content.[4]

One might add, what this table does not show, that the inner portion of grains are poor in most vitamins but the germ and outer layers are valuable sources of the B-complex vitamins, which include vitamin B_1 (thiamine), vitamin B_2 (riboflavin) and nicotinic acid (niacin).

Sugar. This is our most highly refined and concentrated food, for one lump of sugar contains the amount obtained from about three feet of sugar cane. As anything but a luxury, sugar is a comparatively modern food. It was known in Europe only as a curiosity or a medicine until after 1600 and was first sold in small amounts by apothecaries at high prices. Even late in the 1700's, when it had come into quite general use in small amounts for a flavoring material, it sold for over a dollar a pound in France, but by 1825 its cost had been reduced to less than twenty-five cents per pound.

At the time of the Napoleonic wars, when Europe was cut off from its chief source of sugar supply, the West Indies, the manufacture of sugar from beets was developed in France and Germany, the beet-sugar industry thus dating from about 1810. Although by this time sugar had become a necessity rather than a luxury, many people persisted in the belief that sugar made from the beet was not the same as that made from the sugar cane. The force of prejudices concerning foods is well illustrated by the fact that, when sugar was first introduced, it was believed for a long time

[3] This is true except for the appreciable fat content seen in oatmeal.

[4] Whole cereals may be, nevertheless, a valuable source of such mineral elements as iron, copper and manganese.

to be unwholesome (said to be "heating," to injure the chest, to cause apoplexy).

Gradually, however, sugar has become more and more a staple article of diet. Its price has been reduced by improved methods of manufacture and increased supply until it is now one of the cheapest forms in which we can buy energy or fuel supply for the body (a pound of any pure sugar has an energy value of 1807 calories). Moreover, it is such a concentrated and highly purified product that it is clean, keeps well and is easy to ship long distances. Also its sweet flavor is pleasing to the palate and makes more acceptable many rather flat-tasting, bland foods when added to them. Lastly sugar is a habit-forming food, so that persons who acquire a taste for it want more of it as such or want other foods highly flavored with it. Such persons almost invariably interpret this craving for sugar as a sign that "MY system needs sugar," although it is an acquired taste which is not based on physiological need.

All these factors have led to a marked increase in the consumption of sugar. The United States, Great Britain and some nations of the British Commonwealth surpass other countries in the amount of sugar used. The United States has roughly $\frac{1}{16}$ of the population of the world and consumes $\frac{1}{5}$ of the total sugar production. One hundred years ago, our consumption of sugar was about 10 lbs. per person per annum, while recently it has been over 100 lbs. per person each year or about a half pound each day for every person in the country. Of course not all of this is consumed directly but it includes the sugar used in manufactured products like candy, jams and sirups, as well as that used in cooking.

There is no doubt but that as a nation we eat far too much sugar. Our annual candy bill is well over a billion dollars, and has increased over 1000 per cent in the last fifty years. Our acquired taste for sugar has ruined our taste for other foods with more subtle flavors, thus leading us into an unbalanced diet, and has tempted us to habitual overeating, which leads to overweight and all the family of diseases which accompany it, especially diabetes which has doubled its incidence in the United States since 1900. The American people have also become very fond in recent years of various starchy foods such as potatoes, bread and breakfast cereals, even adding sugar to starch in the case of breakfast foods and of griddle cakes with sirup.

Sugar and concentrated sugar products are almost **pure carbohydrates**; they are practically **devoid of mineral salts and vitamins.** Table III, on page 23, shows clearly that sugars and sirups make their sole contribution as foods through their carbohydrate content (fuel value), except for

molasses and sugar cane sirup. As these two products are concentrated, unrefined plant juices, they contain a considerable amount of mineral elements, notably calcium and iron, and small amounts of the B-complex vitamins. Honey also contains some vitamin C (ascorbic acid). Other sugar products are practically negative in protein, mineral and vitamin value. Hence the consumption of large amounts of these foods, with a corresponding diminished consumption of the other classes of food, leads to an unbalanced diet too low in protein, mineral salts and vitamins. If sugar consumption in this country could be reduced to about half its present level, it would be a great thing for the health of the American people.[5]

TABLE III. APPROXIMATE COMPOSITION OF SUGARS AND SIRUPS*

Food.	Carbohydrate.	Protein.	Fat.	Water.	Ash.	Vitamins.
	per cent	*per cent*	*per cent*	*per cent*	*per cent*	
Sugar, white	99.5	—	—	0.5	—	—
" , brown	95.5	—	—	3.0	?	—
" , maple	83.0	—	—	?	?	?
Honey	79.5	0.3	—	20.0	0.2	Traces of B-complex vitamins and vitamin C
Sirup, table blends	74.0	—	—	25.0	Some Ca and Fe	Traces
Sirup, cane (open kettle)	69.0	0.4	—	28.0	2.5	Some B-complex vitamins, notably niacin
Molasses, cane	60.0	—	—	24.0	3.2	Some B-complex vitamins, notably niacin

* Figures chiefly from U. S. Dept. Agriculture, Tables of Food Composition, 1945.

Starchy Vegetables and Fruits. These will be taken up more in detail in the chapter on fruits and vegetables (Chap. 6). Those highest in carbohydrate content have been included in Table I on p. 15, together with the carbohydrate-rich foods, so that the amounts furnished by them may be compared with foods richer in carbohydrate. It will be seen that sugar exists in the juices of fruits in a fairly dilute solution, most fresh fruits being 10–20 per cent sugar as contrasted with the 60–100 per cent found in cane sugar, candy, honey, sirups, molasses, jams and dried fruits. The vegetables listed in the table on p. 15 contain about 15–25 per cent starch as contrasted with the 50–87 per cent starch content of purified starches,

[5] This was accomplished temporarily by sugar rationing (1942–5), made necessary by sugar shortages during the war period.

flours, uncooked breakfast cereals and macaroni, breads, rolls, crackers and dried legumes. In cakes, cookies and puddings part of the carbohydrate content is due to sugar. In some of the vegetables, notably the sweet potato, we have considerable sugar present. It seems wise to emphasize that, in the case of potatoes, beans, peas and green corn, the starch content is too high to be ignored in planning the diet, especially where such large quantities are eaten as is true of potato. Most people recognize the potato as a starchy vegetable, but seem to forget that corn and the legumes are also rich in starch.

Fruits and vegetables which contain utilizable carbohydrates in lesser but appreciable amounts are listed below.

9–15% carbohydrate	Fruits	Apples, apricots (fresh), blueberries, blackberries, cherries (sour), cranberries, currants (fresh), grapefruit, oranges, lemons, loganberries, peaches, pears, plums, pineapples, raspberries.
	Vegetables*	Artichokes (globe), beets, carrots, celery roots, onions, squash (winter), rutabagas, turnips.

*Jerusalem artichoke (tubers), parsnips, and salsify or vegetable oyster have 15–18% carbohydrate content but it is doubtful how much of it is in forms which can be absorbed and utilized by the body.

Place of Sugars and Starchy Foods in the Diet. SUGAR should be reserved for a flavoring material and should be used in moderate amounts. It is a form of concentrated energy or body fuel, but is physiologically injurious when used in a concentrated form and in excessive amounts. Concentrated forms of sugar (candy) may be irritating to the lining of the digestive tract, especially when taken on an empty stomach, and may cause distress by fermenting in the intestine. Lactose and maltose are less likely to ferment than cane-sugar (sucrose). Also, much sugar in the diet may be a factor in causing tooth decay. Since sugar is totally lacking in proteins, mineral salts and vitamins, a very one-sided diet results whenever its excessive use results in the omission or curtailment of foods that furnish these nutritive essentials. If there is no cutting down of other foods, overweight is the result. It has been recommended that not more than 5–10 per cent of the body fuel supply should come from sugar.

STARCHY FOODS (grain products and starchy vegetables) furnish an economical source of energy and protein. They are physiologically a safer food than concentrated sugar and it would be difficult to plan a diet without them. Because of their bland flavor, starchy foods do not produce lack of

appetite for other foods and they can usually be eaten in large amounts without digestive difficulties. Although starch is broken down to sugars in digestion, these sugars (maltose and glucose) are so gradually formed and so quickly disposed of (maltose is further broken down, glucose is absorbed from the intestine) that they ordinarily cause no digestive troubles.

The fact that grain products are an economical source of energy and protein is well brought out in the following results of statistical studies on actual dietaries collected:

Studies by	Grain products cost.	Grain products furnished.	
	Of total expense for food.	Of total fuel supply.	Of total protein supply.
	per cent	*per cent*	*per cent*
Sherman	18	38	37
Univ. of Maine	17	40	25
U. S. Dept. of Agriculture 1945	11	30	28

The more economical the dietary must be the larger will be the place given to the carbohydrate foods, especially the grain products. Where this is true, it is advisable to use whole grain or "enriched" bread (and whole grain or "restored" cereals) instead of highly milled cereal products, and milk in place of water as the fluid for making bread dough. In this way the staple carbohydrate foods of the diet are made to carry as much mineral salts and vitamins as possible; but they are still low in certain of these essential food substances, and their proteins are of such a nature that they need to be supplemented by some proteins of animal origin. The foods which are richest in mineral salts and vitamins, and so are those which should be included in the diet to offset the deficiencies of the carbohydrate-rich foods, are milk and eggs, fruits and vegetables, especially the green or leafy vegetables. Animal protein may be provided by milk, cheese, eggs or meat; other vegetable proteins to some extent supplement those of the cereals, especially those of soybeans and peanuts. A fairly liberal supply of protein, obtained from a variety of foods, is important for health, as well as liberal minerals and vitamins.

In other words a bowl of cereal calls for milk and cream to go with it; a slice of bread calls for fruit or a salad and a serving of potatoes needs one of spinach, egg or meat taken along with it in order to give a balanced diet, which will furnish all the elements needed by the body, In brief, then we may say

Sugars and starchy foods furnish { economical energy supply; some proteins (cereal); flavor (sugar)

Foods needed to supplement carbohydrates { milk, cheese, eggs, or meat; fruits; vegetables

Dietary Rules for the Carbohydrate Foods

Rules as to when and how to eat sugar.....

1. Keep the total amount of sugar in the diet low and do not take much of it in concentrated forms such as candy.
2. Limit candy and other concentrated sweets to a small amount taken at the end of a meal. Hard candies, sweet chocolate, nuts and dried fruits are the best confections.
3. Take most of the sugar intake in more dilute forms such as fresh fruits, and as sweetening in beverages and bland foods such as cereals, cake, pudding, etc. Reserve sweets for the end of the meal (desserts) as much as possible.
4. Avoid sweets between meals but, if candy is taken on an empty stomach, drink at least one glass of water as soon as possible.

Rules about eating starchy foods...

1. Try not to eat more than two foods rich in starch at any one meal. If inclined to be overweight, cut down the amount of starchy food eaten, leaving out bread or potatoes, or eating less of both. In general, it is better to eat more potatoes and less bread.
2. Avoid eating bread, hot bread or cake, which is so fresh or insufficiently baked that the interior makes a sticky, doughy mass when chewed, as such a mass is hard to digest. Hot breads are not necessarily indigestible; if baked till the interior is dry and crumbly, they are not objectionable. Chew such foods thoroughly.
3. Take moderate amounts of the SIMPLE cakes, pastries and puddings and small portions, if any, of those which contain larger amounts of sugar and fats.
4. Take at least part of your cereal foods in the whole grain or enriched form.
5. Accompany starchy foods in the menu with dairy products, eggs, fruit or vegetables as much as possible.

QUESTIONS AND PROBLEMS

1. Name the five different sugars that occur in foods. Which sugar or sugars are found in each of the following foods:

table sugar (granulated, loaf, or powdered)	milk
maple sirup	malted milk
corn sirup	orange
molasses	banana
honey	sweet potato
	candy

2. How do starches from all sources resemble each other chemically and differ physically? What happens to starch granules during cooking? How is starch changed chemically during digestion? Can uncooked starch be digested? From the table on page 15 select ten foods that contain 50 per cent, or more, of starch.

3. What nutritive essential (energy, proteins, minerals, or vitamins) do foods rich in sugar supply and in which ones are they lacking (see table on p. 23)? What nutritive essentials are furnished by foods made from the cereal grains and in which ones are they low or lacking (see table on p. 20)? Name the most important grains and tell where and how each is used for human food.

4. Make a drawing of a kernel of wheat, showing location of outer layers, endosperm and germ and distribution of nutrients in different parts of the kernel. What nutrients are removed, wholly or in part, when the outer layers and germ are removed in milling? What proportion of the wheat kernel is retained in "patent" white flour and how much is it practical to use in flour for bread-making? What is meant by "enriched" flour and "restored" cereals? Is enriched bread, as now sold, fully equivalent in nutritive value to bread made from 100 per cent whole wheat? If so, why and, if not, why not? Why did government authorities sponsor enriched bread?

5. If a sedentary woman needed 2,000 calories of energy each day, she could purchase this much body fuel in the form of bread (1 lb. 11 oz., or about 31 slices) for 24 cents (1947 prices), or in the form of sugar (a little over a pound) for only about 12 cents. Why would it not be possible for her to live on bread alone, or sugar alone? What proportion of the day's calories may safely be taken in the form of sugar, and how much in foods made from the cereal grains? What foods could she use to supplement the nutritional deficiencies of these carbohydrate-rich foods in an adequate diet at low cost? In a more satisfactory diet at higher cost?

6. Which of the following foods, at the prices given, is the most economical source of body fuel? Of protein?

30 gm. (1 oz.)	bread	(1 1/5 slices),	costing	1.35	cents	→	78	calories,	2.5	gm.	protein
" " "	oatmeal (2/3 cup cooked),		"	.8	"	→	119	"	4.3	"	"
" " "	rice krispies (1 cup),		"	2.7	"	→	108	"	1.9	"	"

Which of the foods at prices given below would be the cheapest source of iron, of vitamin B_1 or thiamine? Which would be the most satisfactory source?

30 gm. (1 oz.)	white bread (not enriched)		costing	1.35	cents	→	.24	mg. iron,	.020	mg. vitamin B_1	
" " "	" " (enriched)		"	"	"	→	.60	" "	.072	"	"
" " "	whole wheat bread		"	"	"	→	.75	" "	.083	"	"
" " "	white rice (3/4 cup cooked)		"	1.06	"	→	.20	" "	.015	"	"
" " "	oatmeal (2/3 cup cooked)		"	.8	"	→	1.6	" "	.165	"	"
" " "	Kellogg's all bran (1/2 cup)		"	1.5	"	→	3.0	" "	.110	"	"
" " "	wheat germ (3 tbsp.)		"	1.45	"	→	2.4	" "	.915	"	"

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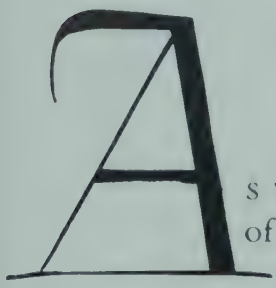
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CHAPTER 3

FATTY FOODS



S WE SAID before, the carbohydrates are almost entirely of vegetable origin and are the fuel (sugars) and storage material (starch) of the plants. **Fats,** on the other hand, are the chief storage material of ANIMALS and so are found mainly in foods of animal origin. Being unable to store any surplus of energy from food as carbohydrate (except the limited amount of "animal starch" in the liver), animals transform such surplus material into fat, which is then tucked away about the organs or in a layer of fatty tissue under the skin.

Uses of Fat Stores in Animals. Such fat deposits serve primarily as a RESERVE SUPPLY OF FUEL to be drawn upon in case of need. Whenever the intake of fuel foodstuffs is insufficient to meet the current body needs, fatty tissues can be burned to make up the temporary shortage and the body does not suffer from any lack of the energy necessary to keep it running smoothly from day to day. Tissue fat thus represents our reserve fuel for emergencies—either for increased needs or shortage of intake. An overfed person will go on storing fat, which he may never need to burn as fuel. In prolonged starvation or after wasting diseases, on the other hand, the body reserves of fat may be completely exhausted.

Fat deposits also serve to SUPPORT and PROTECT THE ORGANS and to PREVENT THE LOSS OF HEAT from the body surface, since fat is a poor conductor of heat or a good insulator. The abdominal fat serves to buoy up the organs and hold them in the position where they can do their work to best advantage. The kidneys especially are held in place largely by fat. Thin persons are more likely to be nervous, to have digestive difficulties, and to feel cold readily than do persons who have a normal amount of abdominal fat and fatty layers under the skin.

Although an excess of fat carries serious disadvantages (see p. 124), a normal amount of fatty tissue is a great factor of safety for the body. A young person who is a LITTLE above the average weight for his height usually possesses a more stable nervous system and is less susceptible to infections than one who is underweight. For these reasons the current craze

among young women for reducing weight to the point of obtaining a "willowy" figure is much to be decried.

Vegetable Fats. Although the fats are mainly of animal origin, a FEW PLANTS possess the ability to STORE FAT in considerable amounts in their fruits or seeds. This is familiar to all of us because we use vegetable oils for food, such as olive oil, peanut oil, cocoanut oil, corn oil and cotton seed oil. The pulp of the nearly ripe olive is so rich in fat that it exudes oil when torn from the stone without any pressure. The greasy feel of the small embryo, or germ, at one end of the grain of corn is likewise familiar—also the fatty texture of many nuts. The nuts are all extremely rich in fat, except the chestnut which owes its mealy texture to the fact that it is poor in fat but rich in starch. Although the peanut is not a true nut but more closely related to the legumes, it is high in fat content. Soybeans, while not in a class with peanuts, have a higher fat content than other legumes and were a valuable source of commercial fats during the recent wartime fat shortage. Of the fruits, only the olive and the avocado or alligator pear show any considerable amount of fat. Many of the seeds and the stones or kernels of fruits (which are of course likewise seeds) are rich in oil content, but few of them now furnish us with oils used for food. The cotton seed (used in America for making a lard substitute and also for salad oil) and the sesame seed (the oil from which is used as a food in Europe) are about the only two seeds whose fat content is at present utilized to any extent for food, although rape seed oil is used in India.

Properties and Digestibility of Fats. It will be noticed that in the above paragraph we speak of the vegetable fats as oils, a term used to signify that at ordinary temperatures these fats are liquids. Many of the animal fats—in fact most of those used for food—are solids or semisolids at the temperatures at which we ordinarily handle them, though they become fluid if heated. Likewise, the fluid fats congeal on chilling, either getting solid throughout (melted animal fats) or becoming turbid with solid particles (vegetable oils). Every fat has its definite MELTING POINT. We all know that butter, which we usually see in the condition of a soft solid, as the Scotch saying runs "twice a year gangs daft," becomes too fluid for comfort in hot weather and too hard to spread easily in winter.

The fats that have the lower melting points digest more readily and completely because they become fluid in the digestive tract. Fats whose melting point is above the temperature of the body remain in solid lumps, which the digestive fluids cannot penetrate, so that they are digested more slowly and often slightly less completely than fats that are fluid at body temperatures. The fats found in milk, cream and egg yolk are those which are the

most readily digested, because they are in a very finely divided state (EMULSIFIED), so that the digestive juices can surround and attack each tiny droplet with ease (see Fig. 4). When cream is churned to make butter, the emulsion is broken up and the fat droplets run together in clumps—hence butter is spoken of as a "FREE fat." Because it is not so finely divided, a free fat cannot be digested as quickly as an emulsified fat. Butter, however, is very readily and completely digested because its melting point is so low. Of the meat fats, pork fat has the lowest melting point and is well digested, beef fat is intermediate, while mutton fat has the highest melting point and is not so completely digested and absorbed as the others. The loss of unabsorbed fat may run as high as 10 per cent with a hard fat like mutton tallow, whose melting point is well above body temperature, but most common fats are 95–99 per cent digested and absorbed.

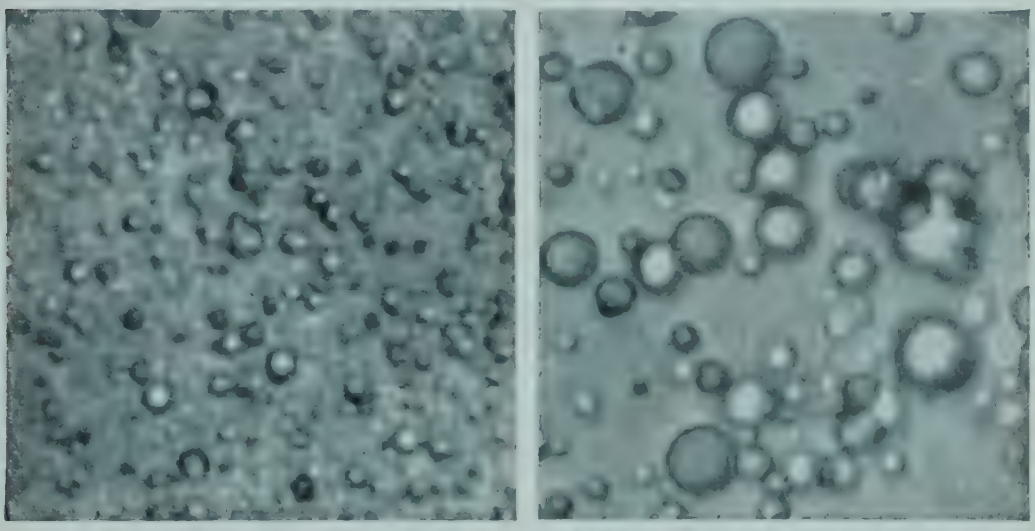


Fig. 4. Fat globules in milk (right) magnified 1000 times; same in evaporated milk (left) broken up so fine that the cream will not rise. (Courtesy of Evaporated Milk Association, Chicago.)

What makes some fats hard and other fats soft, while some are even fluid within the ordinary range of temperatures? It is because they are all just enough different chemically to be different substances, even though they are all closely enough alike to be fats. The fats are a group of substances which are **chemically very similar** and have a **greasy feel**, are **lighter than water** so that they rise to the surface of it, and are **insoluble in water** but soluble in ether. Most of these COMMON PROPERTIES, which all fats possess and by which we recognize a substance as a fat, are familiar to us all. We say "Oil and water won't mix"; we skim cream off the top of milk; we can tell whether there is much or little fat in a food by its texture; we take out a grease spot with ether or gasoline. Fats must all be chemically

much alike (all are salts of fatty acids with an organic alcohol, glycerol), since they all show these same characteristic properties. And yet the minor differences in their chemical composition (differences in fatty acid make-up) cause them to differ in some of their properties. Thus each one has its own melting point so that some are liquid, some semisolids and some hard solids at room temperature.

Nature makes use of these small DIFFERENCES BETWEEN FATS to build fats IN THE VARIOUS ANIMALS whose melting points are such that the fat



Fig. 5. Certain fatty acids, found in fats of low melting point, must be furnished in the food. Skin troubles result, when these essential fatty acids are lacking. Left, six-months-old infant with very resistant eczema since two and one-half months of age. Right, same child six months later after lard had been included in the diet. (Reproduced through the courtesy of Dr. A. E. Hansen.)

will remain fluid at the temperature to which each kind of animal is exposed. Plants and cold blooded animals such as fishes have fats of very low melting points, so that we know these fats only in the fluid state (oils). Carnivorous or omnivorous animals like the pig have softer fats than the herbivorous animals such as cattle and sheep. Finally, even in the same animal the fat at the surface of the body, where it is exposed to cold, may have a slightly lower melting point from that in the interior of the body. Thus nature adapts the fat to the environment of the animal.

Occurrence in Foods. Most of the fats used for food or found mixed with other substances in foods are OF ANIMAL ORIGIN. **Butter,** the most extensively used of all food fats, is made from the milk secreted by animals—usually from the milk of the cow although goat's milk butter is the rule in certain countries. In **milk** and **cream** we use the same fat in greater dilution. **Eggs** are one of our most valuable sources of fat, the fat being contained exclusively in the **yolk. Cheese** which is made from full milk contains a large amount of fat, but skim milk cheese and cottage cheese are low in fat content.

The flesh of animals practically always contains varying amounts of fat between the muscle fibers and larger amounts of clear fat under the skin, which may or may not be included in cooking, or eaten if served with the meat. The quantity of fat in the meat itself varies widely in different cuts (*e. g.*, beef brisket, 30 per cent; beef round, 13 per cent fat) and according to the extent to which the animal has been fattened for market. However, pork usually has a higher fat content than other meats. In **bacon** and **salt pork** we have sections of almost clear fatty tissue used for food. Poultry may contain varying amounts of fat according to the species, the portion of the animal, and whether it has been fattened for market or not. The fat near the skin is frequently discarded in eating. In general, goose, duck, turkey and fowls are rich in fat, while the meat of the breast and of young chickens (broilers) is low in fat content.

FISH store fat in their livers instead of the carbohydrate, "animal starch" or glycogen, found in the livers of other animals. Hence **fish livers** are a source of valuable oils, notably cod liver oil, but on account of their unpalatable taste these oils are reserved for medicinal purposes. The flesh of most fish is poor in fat but a few species form exceptions to the rule and are of higher fat content, *e. g.*, butter-fish, mackerel, herring, shad, salmon, and salmon trout. Sardines, tuna (or tunny) and other fish canned in oil are, of course, rich in fat as eaten.

The **vegetable oils** are practically pure fat and are popular for salad dressings, especially olive oil, but only small amounts of them are used at a time and the dressing may be largely left behind when the salad is eaten. Some vegetable oils are now put through a commercial process (called hardening or HYDROGENATION) by which they are converted to soft solids and they are then of suitable consistency to be used as SUBSTITUTES FOR BUTTER AND LARD. Cotton seed oil, after hardening, is extensively used as a cooking fat (Crisco, Spry, etc.).

Butter substitutes or **margarines** may be made from any blend of wholesome fats which has about the same consistency as butter, and which

can be made to have a somewhat similar taste by churning with cultured skim milk. At first, they were made from animal fats (chiefly oleo oil from beef suet) and the government still requires that they be labeled as "oleomargarine"; this name is misleading, since margarines are now made almost exclusively from vegetable fats (coconut, cottonseed and soybean oils), hardened to the desired consistency by hydrogenation. They can be produced and sold at lower cost than butter and have exactly the same fuel value. Dairy interests early exerted pressure to secure discriminatory taxes and license fees on all margarines and a ten cents per pound tax on colored margarine, which is why one has to buy white margarine and color it in the home. The pigment used is the same as is naturally found in butter and is often added to butter in its preparation for marketing. Although the vegetable fats used in margarines are lacking in the fat-soluble vitamins A and D, normally found in variable amounts in butter, modern margarine manufacturers now add these vitamins in amounts that bring the vitamin A content of margarine up to that of the average in butter. Thus margarines have been made just as good a food nutritionally as butter and the economically minded housewife should be able to buy them free from discriminatory taxes. Formerly, only about one seventh as much margarine as butter was consumed in the United States but, due to high cost and scarcity of butter during and after World War II, many persons managed to overcome a prejudice against margarines, and their use as a table spread, for shortening and for seasoning vegetables has been much increased.

Such oils as those from corn, cottonseed, peanut and soybean make excellent SUBSTITUTES for the more expensive OLIVE OIL for use in salad dressings, and are now widely used. There are no reasons other than a slight real or fancied superiority in flavor why people should be willing to pay a high price for olive oil rather than a lower price for one of the other almost identical vegetable oils.[1]

Other vegetable products used for food, which contain a large amount of fat, are CHOCOLATE and COCOA.[2] PASTRIES, cakes, cookies and doughnuts are foods in which considerable amounts of fat are incorporated along with flour and sugar. The fats used are generally butter, lard or hardened vegetable fats. Macaroons are a confection rich in fat because of the almond meal which they contain.

[1] Salad dressings, either commercial or home made, should NOT be made with mineral oil. Mineral oil, which is a petroleum product and NOT A FAT, has no fuel value and formerly was used in reducing diets but is now considered harmful, since it interferes with absorption of certain minerals and vitamins in the food.

[2] Cocoa is a product prepared from chocolate by removing some of the fat under pressure. The fat thus separated is known as cocoa butter.

TABLE IV. FOODS RICH IN FAT

Animal foods.	Fat.	Vegetable foods.	Fat.
	per cent		*per cent*
Lard	100	Vegetable oils; olive, cottonseed, corn, cocoanut, peanut	100
Butter	81	Salad dressings, mayonnaise	78
Margarine	81	French	39
Salt pork, fat	85	Nuts:	
Bacon, medium	65	Pecans	73
Pork sausage	45	Brazil nuts	65
Cheese:		Walnuts, English	64
American, cheddar	32	Filberts or butternuts	61
Cream, Neufchatel type	37	Almonds	54
Cream:		Coconut, desiccated	39
Light, table or coffee	18–20	Seeds:	
Heavy or whipping	35	Sesame seed	51
Eggs, whole, uncooked	11	Cotton seed	24
Yolks only	32	Legumes:	
Meat and poultry, cooked:		Peanut butter	48
Very fat, medium done	45	Peanuts, roasted	44
Fat, medium done	30	Soybeans, dried, or whole soybean meal	18
Medium fat, medium done	18	Soybeans, fresh	6
Lean, medium done	6	Chocolate, unsweetened	53
Fish, canned, edible portion:		Cocoa, dry powder, avg.	19
Sardines, tunafish, and salmon, avg.	11	Fruit:	
Fish, cooked, edible portion:		Olives, ripe	18
Fatty fish, salmon, butterfish, mackerel, etc.	11–12	Green	13
Dairy products, other than butter, cream and cheese:		Avocados	26
Ice cream, rich	23	Pastries, flour mixtures, etc.:	
Plain	12	Doughnuts	21
Milk, canned (evaporated or condensed)	8	Macaroons	17
Fresh, whole	4	Pie	10–15
		Crackers	5–18
		Cakes	6–23
		Cookies	10–20

Summary. A table showing the relative amounts of fat contained in the various FAT-RICH FOODS is given here (Table IV). It will be seen that our chief uses of fat in concentrated form are confined to butter, margarine and the vegetable oils (80–100 per cent), although the nuts are highly concentrated foods which show 50–70 per cent fat content, and bacon with 65 per cent fat is nearly pure fatty tissue. Foods whose fat content ranges approximately from 20 to 50 per cent include cream and full milk cheeses, egg yolks, fat meats and poultry, fish canned in oil, chocolate, coconut, and

peanut butter. Olives and avocados vary considerably in fat content with different species and degrees of ripeness, with a maximum of 18 per cent for ripe olives, 26 per cent for avocados. Within the range of 7–20 per cent fat content are found such foods as ice cream, oatmeal, pastries, cakes and cookies, as well as the leaner meats and the fat fish.

You will recognize as you scan the list of fat-rich foods in Table IV that we use these foods either in moderate amounts at a time or blended with other foods low in fat content. In other words, while starchy foods form the bulk of our diet, fatty foods are, or should be, more or less of an economic and digestive luxury.

Ways of Serving Fats and Effects in Cookery. In spite of the fact that the fats are rather costly, the flavor which they add to foods is so highly prized that they are extensively used in cookery. We are apt to feel that foods to which no fat has been added taste flat and to enjoy the flavor of "rich" foods (*i. e.*, those that contain much fat). The flavor varies somewhat with the kind of fat used and different nations have preferences for different fats in their cookery, this preference being largely the result of habit and economic conditions.

Fats are practically unaffected by the heat applied in such cooking processes as baking, steaming and boiling, though in the last case there may be considerable fat lost in cooking by melted fat rising to the surface of the water. There is also some loss of fat as drippings in roasting and broiling, but the fat is not decomposed to any extent by the degree of heat used in these processes.

In **frying,** the FAT itself IS HEATED TO quite HIGH TEMPERATURES and, if the fat used is one which decomposes at moderately high temperatures (as is true of butter) or if the high degree of heat is maintained for long, *decomposition products* are formed that are undesirable in flavor and may be irritating to the digestive tract if absorbed into the food. If frying is properly done, food cooked in this way has a crisp coating of highly pleasing flavor, has absorbed little of the frying fat and may be eaten without harm. Foods that have become soggy with absorbed fat will be digested more slowly and may cause distress, chiefly by slowing the emptying of the stomach, although eventually the fat is ordinarily well utilized. Foods fried in deep fat are apt to be more wholesome than those cooked in a frying-pan or sautéed. In general, there is no objection to the use of moderate amounts of properly fried foods by healthy adults and older children. They should not be used too frequently, too many at one time, when overtired or unwell. They are best left out of the diet of young children and persons with impaired digestion.

The presence of any considerable amount of fat in food eaten will slow down the digestion of the whole meal, so that very undesirable effects may follow the eating of "rich" foods. For this reason it is wiser to use fats in moderate amounts applied to the outside of some food low in fat rather than to mix them with the food in cooking. It is better to use butter or margarine on bread and as seasoning on vegetables than as an ingredient in rich pastries, cakes or sauces. Oil is more safely used with vinegar in French salad dressing than when beaten into a flour or egg mixture such as boiled or mayonnaise dressing. A little cheese on a cracker or a few nuts eaten alone at the end of a meal are more wholesome ways of using fatty foods than indulging in such foods as pork sausages, rich gravies or doughnuts where the fat is intimately mixed with starch and protein. The practice of combining one fat-rich food with another, such as heaping mayonnaise dressing on salmon salad, whipped cream on chocolate pudding and ice cream on pie—is distinctly undesirable.

Place of Fats in the Diet. Fats are useful in the diet for three main purposes:

1. As a concentrated form of fuel.
2. For flavor and satiety value.
3. As bearers of vitamin A.

1. The fact that fats are concentrated fuel foods is the most important single item to remember about them. One level tablespoonful of any clear fat is equal in fuel value to one pound of cabbage or one and three fourths pounds of lettuce. THE FATS HAVE $2\frac{1}{4}$ TIMES THE FUEL VALUE OF EITHER CARBOHYDRATES OR PROTEINS IN EQUAL WEIGHTS. For this reason, and also because fatty foods contain little fiber or water, it takes only a small bulk of fat-rich food to increase the fuel value of the diet a great deal.

If you want to put on weight, you can increase the energy value of your diet enormously without being conscious of taking much more food by such simple measures as putting more butter on your bread, drinking milk which is "half and half" (half cream), eating a few strips of bacon for breakfast, using mayonnaise dressing liberally on salad, and taking rich desserts like ice cream. In fact, a few ice cream sodas or a bar of nut chocolate between meals will increase the day's fuel intake surprisingly, while such a dainty as a "double chocolate" sundae garnished with whipped cream and nuts is a large meal in itself.

Overeating of fatty foods, with their high fuel value will lead to storage of energy taken in excess of body needs as fatty tissue, and overweight, with its inconveniences and dangers, will follow. People who are overweight should watch even the small portions of fat carefully. Such persons

seem to have firmly fixed in their minds the rule that "sugar makes fat" but forget that fat makes fat at 2¼ times the rate that sugar does. One will never reduce weight by cutting out all sugars and starchy foods and eating fairly freely of fats. A reducing diet should contain only SMALL amounts of either carbohydrate- or fat-rich foods.

2. It is unnecessary to dwell at length upon the value of fats for **flavor** and **satiety.** Everyone is familiar with the improvement in flavor made by proper seasoning with butter of such foods as white sauce, mashed potato, vegetables, and cakes. The satiety value of fats is not due to their taste, as is the case with sugars. With the exception of butter, fats are practically tasteless, though they seem to impart a texture to the food which most people find pleasing. Nevertheless, persons who want a "staying" meal will usually unconsciously select food which has quite a little fat in it. If it is to be a long time till lunch or a light luncheon is anticipated, one is apt to take a breakfast which includes at least one egg, or bacon, or even ham and eggs. This is because a light breakfast such as toast and coffee would leave the stomach quickly (say in an hour), while the presence of fat in the meal (egg yolk, bacon) will appreciably slow down the emptying time of the stomach. Foods where fat is mixed with protein leave the stomach even more slowly than fats alone. After meals which include considerable amounts of some fatty meat, it may be six hours before the stomach is emptied.

When the stomach is empty, "hunger contractions" set in and, if these are sufficiently strong, one feels a sensation of hunger, On a diet lacking in fat, one may have distressing feelings of hunger even though enough other foods are taken so that there is no loss in weight. On the other hand, the gorged sensation which one sometimes experiences after an extra heavy dinner may mean that the stomach has been so overloaded with rich foods that it will not completely pass on its contents into the intestine before supper time.

As is true of many things, the action of fats in slowing the emptying of the stomach may be good or bad, depending upon their use or abuse. In smaller amounts they are valuable to give a feeling of comfort and satisfaction after taking food. If taken in excessive quantities (several very fatty foods at one meal), digestion in and emptying of the stomach may be slowed down to such an extent that relief is secured by vomiting the meal hours later. Persons differ considerably in the quantities of fatty foods that they can handle without stomach distress, even though the fats are ultimately well digested and absorbed in the intestine.

3. The vitamins have been defined (p. 5) as substances other than car-

bohydrate, fat, protein or mineral salts which are necessary for growth and the maintenance of health. They will be discussed more adequately in Chapters 13 to 16 but it is necessary to touch upon them here to the extent of pointing out that, while the food fats are interchangeable as far as FUEL VALUE goes, they are not identical with regard to their **vitamin content.** VITAMIN A is carried in fats (fat-soluble) and it is relatively ABUNDANT IN BUTTER AND EGG YOLKS, present in smaller amounts in meat fats, and entirely absent from refined fats of vegetable origin. Another fat-soluble vitamin, vitamin D, is furnished in lesser quantities by egg yolks and butter. It is evident then that certain fats are useful as carriers of the fat-soluble vitamins A and D, and in this respect vegetable fats are not complete substitutes for animal fats in the diet.

Vegetable fats are taken in salad oils, shortenings and margarines, all of which are useful fuel foods. Practically all margarines are now "fortified" by the addition of vitamins A and D. Where these vitamins are added in amounts equivalent to those usually found in butter, they have the same nutritive value as butter. (Read the labels on margarines to see whether they contain 9,000 or 15,000 units of vitamin A. The latter is the amount in average butter.) Whether it is advisable to use margarine, either wholly or partly to take the place of butter, should be determined by the amount of money to be spent for food and by the other foods which make up the diet. It should be remembered that egg yolk and the fat in milk also carry vitamin A, while green and yellow vegetables provide a third source of this vitamin. Cod liver oil, which may be given children to supplement diets undesirably low in vitamins A and D, is many times richer in these vitamins than butter. Butter itself is a one-sided food, as it supplies chiefly fuel and vitamin A and is deficient in protein, mineral salts and other vitamins. "If more milk, green vegetables and eggs can be bought by substituting such a product (margarine) for butter, the diet will be improved in many respects."[3]

Summary. As stated above under the uses of fats, they provide energy in concentrated form and some of them are sources of vitamin A. In some of the fat-rich foods the fat present is mixed with protein, *e. g.*, in nuts, meats, eggs, dairy products (milk, cheese, ice cream) and pastries, so that these fatty foods are also carriers of protein. However, most fat-rich foods are deficient in mineral salts, fiber and in vitamins except A, in which the vegetable fats are also totally lacking. **Fats are one-sided foods,** therefore, and need to be supplemented in the diet by foods that are good sources of

[3] Rose, M. S., FOUNDATION OF NUTRITION, 4th ed., rev. by MacLeod and Taylor, The Macmillan Co., p. 399, 1944.

those necessary food elements which the fats lack. Milk, eggs and meat will provide good quality proteins, along with certain minerals and vitamins; whole grain cereals, fruits and vegetables introduce needed fiber, minerals and vitamins. In order to assure a well-balanced diet, it is generally stated that not more than 25–35 per cent of the fuel value of the diet should come from fats. As fats are such a concentrated fuel food, this means a relatively small bulk of them should be taken daily.

Dietary Rules for Fatty Foods

1. Use rather moderate amounts of the fatty foods; avoid taking excessive quantities of fat or many fat-rich foods at one meal; balance fatty foods in the diet with protein-, mineral- and vitamin-bearing foods.

2. Take most of the fat in the more easily digested forms.

More easily digested		Hard to digest
Milk, Egg yolk, Butter, Salad oil	Emulsified	Fat meats
		Rich gravies and sauces
		Rich pastry and cakes
		Foods that have absorbed much fat or become coated with fat in cooking
Ice cream, Cheese, Nuts, Bacon	Uncooked	

3. Include only moderate amounts of the more easily digested forms of fat in the diet of small children and of adults with poor digestion. Exclude fried foods, fat meats, pastry, rich sauces and desserts from the diet entirely under such circumstances.

QUESTIONS AND PROBLEMS

1. What are the distinguishing properties of fats, *i. e.*, the qualities that would identify lard and salad oil as fats, in contrast to carbohydrates such as starch or sugar? Why do all fats show these properties? Why are some fats hard solids, some soft solids, and some liquids at room temperatures? How and why does the melting point of a fat affect its digestibility?

2. In what parts of an animal are fats stored and what are the chief uses of body fat? Why does a man chill more readily than a woman on bathing in cold water? Why does a fat person suffer greater discomfort than a thin person on a hot day? Under what circumstances will body fat be burned up to furnish body fuel? If each ounce of pure fat has a fuel value of 255 calories, for how many calories would one have to draw on body fuel reserves daily in order to lose 1 pound (16 ounces) of body fat in a week?

3. In what respects are vegetable fats identical with and in what respects do they differ from animal fats? Name three vegetable oils used for

food and give their sources; name three foods that consist of vegetable oils changed to solid consistency by "hydrogenation"; name three foods of vegetable origin in which there is a high content of fat mixed with protein. What does margarine consist of, and what is meant by "fortified" margarine? In what respects is margarine equal in nutritional value to butter and in what, if any, does it differ?

4. Why are fats a concentrated source of body fuel? Under what circumstances is high fuel value in small bulk an advantage, when is it disadvantageous? To determine whether fats are as economical a form in which to purchase food energy as carbohydrate-rich foods, get the current prices of the following foods at a nearby market: butter, margarine, lard, bread, sugar. Find the number of calories that could be bought for 1 cent in the case of each food as follows: divide the cost (in cents) of 1 pound of the food into the fuel value of 1 pound of the food, as given below.

Butter	furnishes	3,327	calories	per	pound.
Margarine	"	3,327	"	"	"
Lard	"	4,086	"	"	"
Bread	"	1,186	"	"	"
Sugar	"	1,807	"	"	"

5. What is meant by the following terms: free fats, emulsified fats, homogenized milk? Why are emulsified fats digested more quickly than free fats? Are they any more completely digested in the end? What effect does a meal rich in fat have on the emptying time of the stomach? Why are fatty meats, pastries, sauces, and foods that have absorbed fat in cooking harder to digest than emulsified fats or fat spread on foods like bread or crackers? Name five foods in which the fat is in emulsified form. To what degree are most common fats ultimately digested and absorbed, irrespective of the form in which they are eaten?

6. Name and discuss the three chief uses of fats in the diet. Which nutritive essentials (energy, protein, minerals, vitamins) do they furnish and in which are they lacking? Name four fatty foods that carry vitamins A and D. What types of food are needed to supplement the dietary deficiencies of fats? Why is fat in the diet usually limited to moderate amounts? What proportion of the calorie intake ordinarily comes from fats? Is it necessary to have any fat in the diet and, if so, why?

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CHAPTER 4

PROTEIN-RICH FOODS

THE PROTEINS form another group of organic substances in foods, being one of the three fuel foodstuffs defined on page 6. They all contain the chemical element NITROGEN, in addition to carbon, hydrogen and oxygen. All the proteins also contain small amounts of sulfur and a few of them contain phosphorus or iron. Since carbohydrates and fats are made up of only carbon, hydrogen and oxygen, the body is dependent on the proteins in the food for its nitrogen supply. Both carbohydrates and fats are forms in which surplus energy or fuel is stored, the former being found almost entirely in plants and the latter chiefly in animals. When eaten in the food, both of these classes of compounds serve to supply energy to the body for its internal and external work and in this respect they are interchangeable. In contrast to these substances, the PROTEINS are found UNIVERSALLY DISTRIBUTED throughout the animal and vegetable kingdoms, and, while they can be used to some extent for fuel, their CHIEF FUNCTION IS TO SUPPLY TISSUE BUILDING MATERIAL.

The reason why proteins are so omnipresent in living organisms is that life itself is dependent upon their presence. They are essential constituents in the nucleus and protoplasm of every cell, and hence are necessary for building new tissue and repairing the tissue "wear and tear" occasioned by the life processes. There is no provision for storing excess proteins in either plants or animals. Plants can make new protein for tissue building and repair from simple substances in the soil and air, but animals are dependent upon the proteins in plants or other animals taken as food to supply them with nitrogen-containing substances in a form which they can use. If we ate no protein, the tissues would slowly starve to death, even though plenty of carbohydrate and fat were available for fuel supply. The importance of this class of substances to the life processes is reflected in the name given them, the word protein coming from a Greek verb which means "to come first."

Properties and Occurrence of Protein in Foods. As has been said, proteins are present in all living tissue, or that which was once living, but

they are usually so intimately mixed with other types of material, such as connective tissue (or fiber), fatty material, mineral salts and water, that it is difficult to give examples of pure protein substances from which the reader can get an idea of what proteins are like. Almost the only instance of a food protein unmixed with other material is found in egg white, which is practically pure protein in solution in water.

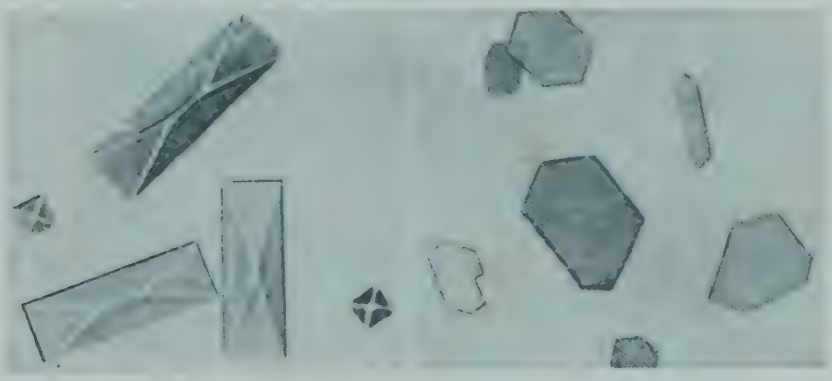
Proteins are **complex substances,** most of which do not dissolve very readily in water; when they do, **sticky opaque solutions** like egg white are the result. It is also characteristic of them that they **coagulate on heating.** Egg yolk, meats, and cheese are other foods which have large amounts of protein in them but here the protein is mixed with a good deal of fat or connective tissue. It will be remembered that all these foods toughen and harden on heating, an effect due to the coagulation of the protein in them.

It should be borne in mind that there are smaller amounts of protein in practically all the other foods we eat. Only in such lifeless substances as salt, and in pure sugar or fats, will it be entirely lacking, although the amounts present in fatty tissue and the storage parts of plants like tubers and seeds is very small. The protein in grains is more concentrated in the embryo and outer coats, although there are smaller amounts throughout the starchy interior which forms the bulk of the kernel. In nuts we have much protein mixed with fat, while peas and beans show a considerable amount of it blended with larger amounts of starch. The soybean differs from other legumes in that it has a higher protein and much higher fat content, with correspondingly less starch.

We have said that proteins are complex substances. In this they resemble starch, while the fats and sugars are relatively much more simple. In the chapter on carbohydrates (p. 12), we described starch as a complex substance made up of many sugar groups linked together. Proteins are similar in that they ARE MADE UP OF MANY SIMPLE NITROGENOUS COMPOUNDS LINKED TOGETHER. These simple, nitrogen-containing substances which unite to form proteins are called **amino acids.** However, all the sugar groups by whose union starch is formed are alike, while at least twenty-one DIFFERENT amino acids may enter into combination in forming protein. Thus starch is always chemically the same wherever we find it in nature; nothing enters into its composition but many identical sugar groups (glucose) so that when it is broken down in digestion, glucose alone is the final product. In contrast to this, we find there are a great many different proteins, all similar in composition in some respects but containing different amino acids combined in different relative amounts. When the link-

ages which hold them together are broken down in digestion, the proteins fall apart into the various amino acids of which they were originally built.

Amino acids are the **building stones** of which proteins are made, and they all contain that element which is peculiar to proteins, **nitrogen.** Although some 30 amino acids are said to have been obtained from different proteins, only 21 of these are commonly present in proteins. It has been estimated that over 350 million times a million different combinations of these 21 commonly occurring amino acids are possible, provided each one of them is used only once. The number of proteins which are theoretically possible is thus so great as to be beyond the grasp of our minds, but we can realize what exceedingly complex substances they must be. It is no wonder that man has not yet been able to make a true protein in the laboratory!



A B

Fig. 6. Crystals of two pure amino acids. A, Alanine, B, valine crystals. Alanine is not an essential amino acid but valine is. (Sahyun: Outline of the Amino Acids and Proteins. Reinhold Publishing Corp.)

Complete and Incomplete Proteins. Of course Nature does not put them together with just one of each amino acid in every protein molecule. She often puts in much of one building stone and only a little of another, and occasionally leaves out one or more amino acids entirely in making certain proteins, though the same protein is always built exactly alike. More than 50 different proteins have been purified and studied as to their amino acid make-up and they have been found to contain usually 12-18 amino acids in varying relative amounts.

Now not all of the amino acids have to be furnished to the body in the food. Some of the simpler ones can be formed in the tissues from what we might call the scraps left over when other amino acids are used up. These nitrogen-containing fragments are probably united with simple organic compounds, formed from carbohydrates in the course of tissue oxidations.

and worked over to yield amino acids. Of course, it would be harder for the body to make the more complex ones in this way, so that we find there are a number of amino acids (about 10) which the body cannot make and which must be furnished in the food. These are called **essential amino acids.**

If any protein is completely lacking in one of these essential amino acids, it naturally will not suffice to build and repair tissues. Growth cannot take place or an adult be maintained in health, if this is the only protein in the diet. Such a protein is called an INCOMPLETE or **deficient protein.** A COMPLETE protein is one which contains ALL of the essential amino

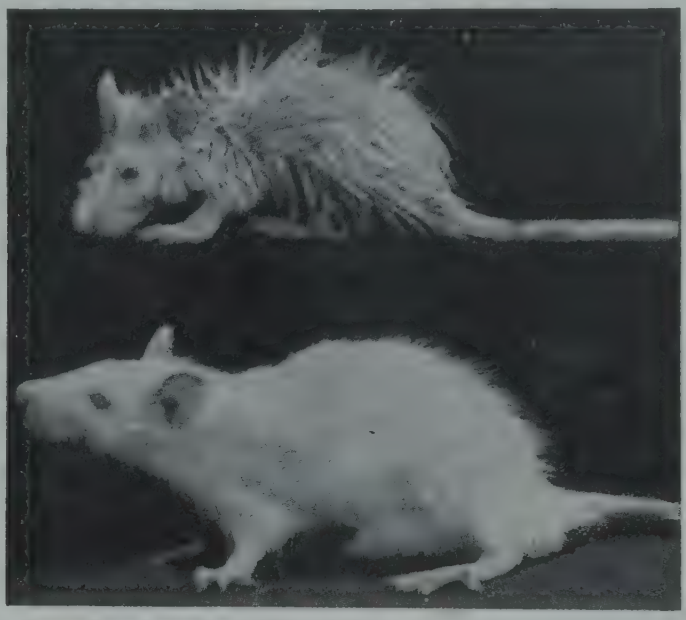


Fig. 7. Effects of lack of one of the essential amino acids. Upper photograph shows a rat on the 28th day of valine deprivation. The lower photograph shows the same animal after valine had been administered for 25 days. (Rose and Eppstein: J. Biol. Chem. Vol. 127.)

acids, *i. e.*, those which must be supplied performed in food. Such a protein is said to be **adequate** for both growth and maintenance. Incomplete proteins would not do, of course, as the SOLE source of protein in the diet (see Fig. 9, p. 48), but so long as SOME protein is taken which provides the minimum quantity of each building stone needed, the body can meet its needs for tissue building and repair.

These amino acid building stones have also been spoken of as the letters of the protein alphabet and in building tissue proteins it is as if the body were playing a kind of anagram game with them. "It would be like taking the word LEGUME apart and trying to make the word MUSCLE. We should have a superfluous 'g' and 'e,' but no 's' nor 'c,' and be forced to break

up another word, such as CASEIN, to get the extra letters."[1] LEGUME would represent a deficient protein in the food and CASEIN would supplement it by supplying amino acids (represented by the letter "s" and "c") lacking in the first protein. This illustration also serves to emphasize why the body cannot use the food proteins as such to build tissues. They must first be broken down by digestion into their constituent parts (the amino acids, letters of the protein alphabet); the body then takes the various amino acids, rearranges and recombines them to make quite different proteins for the tissues, a process analogous to putting the letters together to form another word.

Not very many of our food proteins are incomplete and these **deficient proteins are found** almost entirely **in vegetable foods.** GELATIN is the only animal protein which is deficient. It is completely lacking in two of the amino acids which have to be supplied in the food, and contains only



Fig. 8. Stunting of growth due to inadequate amount of protein. Rat at left had 18 per cent protein in diet, while the stunted one at right had only 4 per cent. The protein was a complete one but insufficient in quantity to support normal growth. (Cooper, Barber and Mitchell: Nutrition in Health and Disease, 10th ed., J. B. Lippincott Co.)

very small amounts of two other necessary amino acids. When a protein is very low on any essential amino acid it may be practically as bad as if it furnished none. It is just as if we needed to make the word muscle 100 times and had only two or three of the letters "s" and "c." It is obvious that we could make muscle only two or three times, though we would have a great superfluity of all the other letters. In the same way a diet which provides only a small amount of any essential amino acid may hold up protein building in the tissues.

Growth may be stunted (see Figs. 7, 8 and 9) by the complete lack or insufficient supply of ANY component necessary to build tissues (which includes not only essential amino acids but also mineral salts and vitamins). A diet which is very low in some one of these necessary substances may

[1] M. S. Rose, FEEDING THE FAMILY, 4th ed., Macmillan, p. 16, 1940. Casein is the name of the chief protein in milk.

even be inadequate to meet the need for REPAIRING WEAR AND TEAR ON TISSUE already built, so that an adult could not be kept in health for very long on such foods.

Fortunately proteins that are incomplete are often found mixed with other supplementary proteins even in the same food, or a small amount of another food may serve to supplement their amino acid make-up. Thus wheat, rye, barley, and corn each contain one incomplete protein, but they also carry some complete proteins which (if not removed in milling) will furnish most or all of the essential amino acids lacking in the others. Like-



Fig. 9. Stunting of growth due to feeding an incomplete protein as sole source of protein in the diet. Contrast between two rats of the same age kept on diets alike except for the protein, which was a complete protein (casein from milk) in the case of A, and an incomplete protein in the case of B (gliadin from wheat). (From experiments by Osborne and Mendel, Conn. Agr. Exp. Sta.; pictures reproduced by courtesy of Yale University Press.)

wise most of the legumes contain both complete and incomplete proteins. Casein, one of the proteins of milk, is rather low in one amino acid but this is supplied in liberal amounts by the other protein of milk. In general, the proteins of milk are especially valuable in supplementing those of the grains, and complete proteins found in animal foods (milk, eggs, meat) supply liberal quantities of amino acids needed for growth and furnished in lesser amounts by most vegetable foods. A young pig will not grow well on corn alone but a relatively small amount of milk will suffice to make a mixture of corn and milk proteins that is adequate for good growth. Soybean flour, at levels of 10 to 15 per cent, supplements the protein of

white wheat flour with an effectiveness that ranks with that of the proteins of meat, eggs and milk. Peanut butter proteins are also a valuable supplement to those of bread and even the incomplete proteins of beans have an amino acid contribution to make in a mixed diet.

It used to be said that, in order to assure good growth, at least $\frac{2}{3}$ of the protein in the diet of children should come from animal foods. This is still a pretty good rule to follow, if possible, because milk should bulk large in the diets of growing children for its mineral and vitamin values, as well as for its proteins of "**high biological value.**" By the latter expression we mean proteins that are complete and provide essential amino acids needed for building tissues. Modern nutrition research has emphasized the importance, even for the adult, of a liberal supply of proteins of high biological value. However, the distinction between animal and vegetable proteins is not made so sharply as formerly, since vegetable proteins supplement each other and some of them (*e. g.*, soybean and peanut proteins) have been shown to have excellent biological value. We do stress the fact that, for adequate growth in childhood and best health in later life, the protein in the diet should come from a wide variety of foods, and a goodly portion should be supplied by foods that carry complete proteins.

We have gone into the subject of incomplete proteins rather fully for two reasons; (1) to reassure the reader that foods which contain such proteins have a valid place in the diet and contribute come valuable food elements, (2) to stress the fact that the protein supply should come from quite a wide variety of foods in order to serve the body needs to best advantage. If a number of protein-rich foods of both vegetable and animal origin are used, the bogey of incomplete proteins need not be feared. So far as our protein supply goes, there is safety in mixtures.

Occurrence in Food. The most IMPORTANT PROTEIN-BEARING FOODS, together with the relative amounts of protein they contain, are listed in Table V. Some of the foods listed, such as milk and the cereal products, could scarcely be called protein-rich foods, but are used in sufficient amounts to contribute appreciably to the protein supply. The GRAINS AND LEGUMES furnish our most ECONOMICAL sources of protein. MILK and CHEESES provide valuable proteins at moderate cost, while MEAT, EGGS and NUTS carry considerable amounts but at somewhat higher cost. Even those foods which might be classed as protein-RICH are only one-sixth to one-third protein (about 16–33 per cent in most meats, legumes, nuts and cheeses). Contrast this with carbohydrate-rich and fat-rich foods, like refined sugars, starchy foods, butter and salad oils, which often consist of

TABLE V. PROTEIN FOODS

Animal.	Protein.	Vegetable.	Protein.
	per cent		*per cent*
Gelatin, plain, dry	86	Nuts, edible portion:	
Cheese:		Butternuts	24
Roquefort	22	Almonds	19
American, cheddar	24	Walnuts	15
Swiss	25	Brazil nuts	14
Cottage (from skim milk)	19	Filberts (or hazel nuts)	12
Cream (Neufchatel type)	7	Pecans	9
Meat and poultry, cooked:		Legumes:	
Lean, medium done	30	Soybeans, dried	35
Medium fat, medium done	27	Peanuts, roasted	27
Fat, medium done	22	Lentils, dried	25
Organ meats, uncooked:		Peas, dried	24
Liver	19–22	Cowpeas, dried	23
Kidneys	15–17	Beans, dried	22
Heart	16	Fresh	7–8
Sweetbreads	15	Peas, green, fresh	7
Fish, cooked, edible portion	19–24	Cereal products:	
Shellfish, edible portion:		Oatmeal, uncooked	14
Shrimp, canned	18	Macaroni, uncooked	13
Lobster, boiled	16	Wheat breakfast foods, dry, uncooked	10–12
Crab, fresh or cooked	16	Crackers	8–11
Clams, fresh	11–13	Bread:	
Canned	16	Whole wheat	9.5
Oysters, fresh or canned	10	White	8.5
Eggs, whole, edible portion	13	Rye	6
Milk:		Wheat germ, commercial	25
Dried, skim	35		
Evaporated or condensed	7–8		
Whole, fresh, avg.	3.5		

almost pure carbohydrate or fat. Protein is a very valuable substance for both plants and animals but is needed only in moderate amounts.

Almost all foods furnish some protein. Those not listed in this table usually have a protein content of less than 10 per cent but many of them carry as much as 4–8 per cent protein. Even the fruits and vegetables, which are so high in water content, furnish appreciable amounts of well-utilized proteins. The protein content of fruits is approximately 0.5 per cent to 2 per cent, while that of vegetables other than legumes ranges from 1 to 4 per cent. Only such highly purified foods as cane sugar and sirups made from it, corn starch, arrowroot starch, lard, the vegetable oils and shortenings made from them are almost entirely lacking in protein.

GENERAL INFORMATION ABOUT PROTEIN-RICH FOODS

Flesh Foods (MEATS, POULTRY AND FISH). These foods may be treated as a group because of the **similarity** in their **composition** and place in the diet. The flesh of all animals, whether mammals, birds, fish, or shellfish is essentially the same. There is sometimes more difference in composition in flesh from different portions of the same animal than the usual variations between different animals. Likewise the method of cooking and the texture of meats may be of more importance in regard to their digestibility and nutritive value than minor chemical differences. In this discussion we are using the term meat to include the flesh of all animals used for food.

Flesh foods, *i. e.*, the LEAN part of the meat as eaten, may be described as consisting of approximately $\frac{1}{5}$ protein, $\frac{3}{4}$ water, and $\frac{1}{100}$ ash, with varying small amounts of fat. There is practically no carbohydrate in meats.

Looked at in another way, meats may be said to consist of:

(1) The PROTOPLASM, or lean part of the meat described above;
(2) The CONNECTIVE TISSUE, which holds the muscle fibers[2] together;
(3) The FAT, which is usually found in a layer near the surface but which is deposited between the muscle fibers in some meats;
(4) EXTRACTIVES and SALTS, which are found in the protoplasm.

The amount of **connective tissue** present largely determines whether a meat is tender or tough. There is less of it in the flesh of young animals, and in those parts of the body where the muscles are not much used; there is more of it in older animals and those which have been allowed to exercise a great deal. All meats, except those from very young animals, need to "hang" at least a few days in order that the lactic acid formed in them may have a chance to soften the connective tissue, otherwise they will be tough and "stringy." In the process of cooking, moisture and heat act upon the connective tissue, softening it and eventually converting it into gelatin, so that the fibers of thoroughly cooked meats tend to fall apart easily. Less expensive cuts of meat, which are tougher than the more costly cuts, may thus be rendered palatable by softening the connective tissue through long, slow cooking (*e. g.*, pot roasts, stews, etc.). It is important to remember that there is little or no difference in nutritive value between the much-prized cuts of meat and those often discarded, so that the economic waste thus incurred is very great and the utilization of the cheaper cuts of meat is much to be encouraged.

[2] The student should not confuse the muscle fibers of meat held together by connective tissue (both of which are digestible) with the indigestible material (cellulose) of which the woody and fibrous parts of plants consist. Hence, when one speaks of the INDIGESTIBLE FIBER content of foods only the vegetable (and NOT animal) fiber is included.

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Variations in the composition of meats are chiefly due to **differences in** the amount of **water** or **fat** present in the tissue. These are a good deal dependent on the species, *e. g.*, fish is usually higher in moisture content than beef or mutton; salmon is relatively high in fat content as compared with cod or flounder; and pork is richer in fat than most other meats. Even within the same animal the fat content may vary a good deal with cuts from different parts of the animal (beef brisket, 30 per cent; round, 13 per cent fat). Also the fat content is naturally an index of the nutritive condition of the animal, *e. g.*, older animals are usually fatter than young ones, corn fed or otherwise well-fed animals than underfed ones, and those that have been confined than those that have been allowed to run.

Much of the fat that is deposited in a layer just under the skin is trimmed off by the butcher or in the kitchen, and most of the remainder is discarded in eating. Such fat does not add to the nutritive value of the meat except as it is eaten with the meat, or is salvaged in the kitchen, rendered and used for cooking fat. However, when the fat is intimately mixed with the meat so that it is eaten, it adds greatly to the fuel value, but it also acts to slow down the digestion. A certain amount of fat improves the flavor of the meat. Thus the capon, a male chicken which has been castrated and which, as a result, tends to put on fat, is especially prized for its flavor, as well as for the larger proportion of light meat and finer texture of the flesh.

Meats owe their appetizing taste and their pleasing variety of flavor chiefly to the **extractives** which they contain. These, as their name implies, are readily soluble in water and are extracted in soup making. They have a mildly STIMULATING EFFECT on both APPETITE and DIGESTION, which justifies the use of meat broths at the beginning of a meal.

All meats are **acid-forming,** due to the nature of the MINERAL ELEMENTS that they contain. They furnish a great deal of the acid-forming elements PHOSPHORUS and SULFUR (see list on p. 5), and are poor in the base-forming elements, especially calcium which is needed by the body for bone building and other functions.

Meats are popularly supposed to be an especially valuable source of IRON. While they do furnish fairly liberal amounts of this element, many other foods contain as much or more and, except for the organs such as liver, kidney and heart, meats may be over-emphasized as a source of iron. Probably only about half of the iron in muscle meats is in forms that can be readily assimilated and used by the body for building blood. Liver and kidney are among our best sources of iron, and practically 100 per cent of their iron content is available for blood regeneration.

Most muscle meats are good sources of all the B-complex vitamins, es-

pecially niacin; organ meats are relatively rich in these vitamins and also in vitamin A. Pork is exceptionally high in vitamin B_1 (thiamine); it carries about seven or eight times as much of this vitamin as other meats. Meats contain very little vitamin C (ascorbic acid) even in the raw state, none after cooking; there is loss of some B-complex vitamins in cooking, varying with the vitamin and method of cooking. As much as 50–75 per cent of the vitamin B_1 may be lost in stewing or braising, 30–40 per cent in broiling or roasting, 15 per cent in frying.

The **digestibility** of meats is excellent, the proteins being 97–98 per cent and the fat about 95 per cent digested and absorbed. It will be seen that little residue would be left from meats in the alimentary canal, and in this sense they may be constipating. Ways of cooking, texture and fat content all influence digestibility somewhat, but their influence is chiefly confined to ease and rate of digestion in the stomach and length of time the food remains in that organ, rather than to the extent of final digestion in the intestine. Meats which are tough, dried out in cooking, cooked with fat, insufficiently chewed, or high in fat content (pork) will digest more slowly and may cause gastric distress. However, properly cooked meats, eaten in moderate amounts, are not only well digested themselves but seem to stimulate the digestion of other foods in the stomach.

The **proteins** of meats are of high quality and serve to supplement those of the grains, but are in no way superior to those of milk and eggs for this purpose. Only in protein do the meats supplement grains, as otherwise they have the same deficiencies as the cereals (chiefly, lack of calcium and vitamins A and C).

DIFFERENCES BETWEEN FLESH FOODS

Meats. Meats, in the ordinary sense of the term, include beef, mutton, pork, lamb and veal. They seem to be a little richer than other flesh foods in the extractives, which give flavor and stimulating effect. They may contain more connective tissue or fat than some other types of flesh such as the tender white meat of chicken or those fish low in fat content.

Poultry. The flesh of birds is very similar to that of mammals. It is especially prized for its palatability and for the variety it adds to the diet. Although very popular, poultry is the most expensive of the flesh foods, chiefly because of the large amount of waste in the carcass. The white meat of chicken (breast) is especially easily digested and low in residue, due to the fact that it has looser texture, shorter fibers, and less connective tissue and fat than almost any other meat.

Fish. Though essentially similar to the other flesh foods, fish has less

extractives, less iron, and usually a higher water content. The different species vary a good deal in fat content, and the flesh of some fish is almost totally lacking in fat. There is no warrant for the popular misconception that fish has special powers as a brain food. It is high in phosphorus content but so are the other flesh foods, milk and eggs, and phosphorus is NOT specifically a brain-building element. Salt water fishes may be a source of iodine, an element which is very scarce in most foods. Fish oils are rich in vitamins A and D, but most people do not care to eat the high-flavored fat of fishes. Hence, fish are chiefly valuable as a source of protein, to give variety in the diet by substituting for meat in this respect. As fish is one of the most difficult foods to keep so that it retains its fresh flavor, it is a satisfactory, inexpensive food chiefly in regions near the source of supply. Recent development of the canning and "quick-freezing" industries, as well as improvements in refrigeration during shipping and some quick transportation by air, have done much to extend the season for certain fish and to bring it to distant consumers in palatable condition. In comparison with choice cuts of meat, even relatively expensive kinds of fish may be fairly economical sources of protein.

Shellfish. These fall into two classes: (1) mollusks, including oysters, clams, and scallops; (2) crustaceans, including lobsters, crabs and shrimps. They do not differ much in composition or digestibility from the other flesh foods, except that they contain considerable amounts of a carbohydrate called "glycogen." Their proteins are efficient or complete. They are valued chiefly for variety and palatability, as well as for sources of protein and iodine, while oysters are especially rich in iron and copper. All fish and shellfish (as well as meats and poultry) contain a preponderance of acid-forming elements, and oysters are especially high in this respect. If not fresh or if eaten in too large amounts, they may cause severe digestive upsets. Likewise they are dangerous if contaminated with bacteria from sewage and eaten raw or only slightly cooked.

Organs. Ordinarily these are not much eaten in this country, though in Europe, where there is much less waste of food materials, they are often favorite articles of diet. From a nutritive standpoint they are valuable foods, as they contain more minerals (especially iron) and vitamins than the muscle meats, and also provide protein of high quality. Their fairly frequent use by most persons is beneficial.

Liver contains substances, in addition to iron and copper, which act to stimulate the formation of red blood corpuscles, so that it is a most valuable food in cases of anemia. The organs usually eaten are liver, kidneys and heart, with the thymus glands used under the name of sweetbreads.

The tongue is also frequently esteemed as a food but should be classed with the muscle meats rather than with the organs.

Place of Flesh Foods in the Diet. Meats are especially valuable for palatability and for the proteins of high biological value that they supply, although their proteins are in no way superior to those of milk and eggs. The use of meats is one of the simplest means of making meals acceptable, and considerable ingenuity and culinary skill are needed to make a diet satisfying when meat is eliminated or obtainable only in small quantities. Given an adequate supply and plentiful means, most people would like to eat meat rather liberally. But meats are relatively expensive foods. In a recent (1942) survey of American family dietaries, an average of 30 per cent of the food money was spent for meat, fish, poultry and eggs, foods which contributed 33 per cent of the proteins of the diet, considerable iron and B-complex vitamins, but only a small per cent of the calcium quota and a negligible amount of vitamin C. When less money is spent for meat and more for milk, fruits and vegetables, the diet is usually better balanced nutritionally. Moreover, the raising of many animals for meat is an uneconomical use of the nation's food supply, especially if they are fed grain that might be used for milk cows or human food. Only when cattle and sheep are raised on grazing lands, pigs and chickens more or less on refuse, does meat production represent the most economical use of national resources.

Under pioneering conditions meat is always plentiful and relatively cheap. Our forefathers seem to have eaten enormous quantities of meat, and while they led an active, outdoor life and seemingly did not suffer greatly from this diet, we have no means of knowing how many of their ailments were the indirect result of dietary indiscretions. It is interesting to find a description of the supper served upon the occasion of the ordination of a new pastor of the Old South Church in Boston in February, 1761[3] —"There were six tables that held one with another eighteen persons each, upon each table a good rich plumb pudding, a dish of boil'd pork and fowls, and a corned leg of pork with sauce proper for it, a leg of bacon, a piece of alamode beef, a leg of mutton with caper sauce, a roast line of veal, a roast turkey, a venison pastee, besides chess cakes and tarts, cheese and butter. They had plenty of old cyder, one barrel of Lisbon wine, punch in plenty before and after dinner, made of old Barbados spirit." It would be difficult to match such a meal anywhere today as to the amount of meat consumed at one sitting. However, the passing of the "meat for breakfast"

[3] From "The Sabbath in Puritan New England" by Alice Morse Earle, Scribners, 1892.

TABLE VI. MEATS AS FOODS

Advantages.	Disadvantages.	How met.
Flavor (extractives): Stimulate appetite. Stimulate digestion.	Expensive.	Use less meat and more meat substitutes. Use less expensive cuts of meats.
Easily cooked and give sense of satiety.	Acid-forming.	Offset this by eating base-forming foods: milk, vegetables, fruits.
Well digested and absorbed.	Poor in: calcium, some vitamins, roughage.	Supplement it in these respects by taking liberal amounts of: milk, vegetables, fruits.
Furnish: fuel, complete proteins, iron.	Contain uric acid forming substances.	Cut down on amount of meat, especially organ meats, in case of any trouble in excreting uric acid.
	May favor intestinal putrefaction.	Eat less meat and more carbohydrate foods—also use intestinal hygiene.
	May be contaminated with bacteria.	Health inspection of foods at source. Keep well refrigerated. Cook thoroughly.

era, which meant meat three times a day, took place only at about the turn of the century (1900).

Even yet meat consumption in the United States is fairly high and a larger amount is spent for it than for any other food. Our annual meat consumption (including fish and poultry) averaged about 162 lbs. per capita during the pre-war years 1935–39, or 7 oz. daily for every man, woman and child. As young children and many other persons eat less than this, while infants eat no meat at all, some people in the country must be eating a larger amount to keep up the average. Only in Canada, Australia, New Zealand and the Argentine is more meat eaten than in the United States; numerous European countries eat about half as much as we do, while in Asia meat is a very scarce food. Because it has large areas of land for which grazing is the most advantageous use, the United States will probably continue as a meat-producing, and hence a relatively high meat-consuming, country.

Should we cut down our consumption of meats in the interests of good nutrition? This is a question that has been agitated for some time. Meats

are an excellent food but have some deficiencies and disadvantages (see Table VI on p. 56). The physiological disadvantages of meats are that they are acid-forming foods, contribute rather liberally to the formation of uric acid in the body, and that the burning of much protein material in the tissues and the excretion of the waste products thus formed may place an undue burden on the liver and kidneys. Also a high-protein diet may contribute to intestinal putrefaction. It should be remembered that none of these ill-effects is confined to meat but that overindulgence in any or all HIGH-protein foods may have similar disadvantages. No disastrous effects need follow the use of meats or other protein foods, provided the diet does not become too one-sided by the omission of other foods. Fruits and vegetables, cereals and dairy products are all needed to balance the acid-forming properties of protein, to promote intestinal hygiene, and to provide calcium, vitamins A and C, and any other nutritive essentials in which meats are deficient. Hence, a well-balanced dietary is more important than the exact quantity of meat eaten.

Formerly nutritionists were apt to urge a sharp cutting down on meats in favor of these other foods, but recently there has been emphasis on the fact that high quality proteins (such as in meats, milk and eggs) are needed for growth and health. The League of Nations in 1935 recommended 23 oz. of meat per week, or about 75 lbs. per person per year; recent recommendations of British and American experts place a level of about 80–100 lbs. annual per capita consumption as adequate. These figures are for beef, lamb and pork (exclusive of fish and poultry), of which the 1945 consumption in the United States was 130 lbs. per person (or 2.5 lbs. per week). Thus it would seem that we might cut down our meat consumption by $\frac{1}{3}$ and still have an adequate diet. However, the trouble in this country is uneven distribution more than too high total consumption. If those who are large meat-eaters would eat less and those with less liberal incomes could have more meat, the more equitable distribution of meats might bring nutritional benefits to both classes as well as decreasing envy of the "haves" by the "have nots." At present most American families probably spend between $\frac{1}{6}$ and $\frac{1}{2}$ of their total expenditure for food on meats.

Eggs. Eggs are more nearly interchangeable with milk than any other food, though there are some decided differences between them. The main differences between the two foods are that (1) milk has a high calcium content while eggs are of lower calcium content,[1] (2) eggs are rich in iron in which milk is rather lacking, and (3) eggs are a highly acid-forming food

[1] As calcium is such an important element for bone building, eggs cannot entirely take the place of milk in the diet, especially for children.

while milk furnishes a slight excess of base-forming elements to the body. Thus to some extent they supplement each other. Eggs are very easily and completely digested, and are a good **fuel food** in addition to being a good **source of protein.** The proteins of eggs are practically as efficient for promoting growth and for supplementing deficient vegetable proteins as are those of milk. Eggs are a less economical way to buy protein than milk and cheese, but usually provide it at lower cost than meat and in addition are **rich in** certain **mineral salts** and **vitamins** which meat lacks.

The **composition** of eggs can be summarized as approximately $\frac{3}{4}$ water, $\frac{1}{8}$ protein and $\frac{1}{8}$ fat. The protein is about equally distributed between the white and the yolk but all of the fat, as well as the mineral salts and vitamins (except B_2 or riboflavin), are in the yolk. Egg fat, like milk fat, is emulsified or finely divided so that it is digested with special ease.

As the **yolk** contains the greater part of the nutritive value of the egg and is apt to be better tolerated by young children than the white, it is usually given alone (either soft or hard-cooked and crumbly) when eggs are first introduced into the diet. Egg yolk, like milk, is prepared by nature to serve as a food for young animals. The greenish color which develops on the outside of the yolk in cooking is due to a combination of iron and sulfur, in both of which elements the egg is very rich, and has no bearing on the freshness or food value of the egg.

The differences in prices charged for eggs are based on **degree of freshness** and size. Since eggs are subject to bacterial decomposition, they must be marketed as soon as possible or kept at temperatures slightly above freezing. While some persons have a prejudice against cold storage eggs, the development of cold storage facilities has been most useful in preserving eggs from seasons of surplus so that they may be available in times of scarcity and in equalizing the price of eggs throughout the year. The qualities of freshness are not dependent solely on age, and properly handled cold storage eggs are often superior to so-called "fresh" eggs which have been laid in dirty nests and marketed only after a considerable delay, during which they were not refrigerated. The color of the egg shell, while taken into consideration in grading, is without significance as to freshness or nutritive value.

The way in which eggs are cooked makes some slight difference in their **digestibility** but not so much as usually supposed. The influence of cooking is chiefly in altering the speed with which they are digested but, given sufficient time, they are eventually very well digested and absorbed no matter how they are cooked. The white of fried or hard-boiled eggs will digest rather more slowly than when soft-cooked, unless it is very well chewed or put through a ricer or sieve.

Raw egg white is slightly less well digested than cooked and, when eggs are used raw, better utilization will be obtained if they are thoroughly beaten. When the sole protein fed to animals, raw egg white will produce skin rash and other symptoms, which have been shown to be due to deficiency of one of the B-complex vitamins.[5] A substance in the raw egg white combines with the vitamin in food and prevents its absorption. Shortage of this vitamin (biotin) has been experimentally produced in man by feeding raw egg white.[6]

Eggs are easily cooked in a variety of ways so that they form an acceptable **meat substitute** and **supplement for milk** as a protein-bearing food. They are especially useful for combining with other foods **in cookery,** where they serve the purposes of THICKENING (as in custards), or of STIFFENING and LIGHTENING texture (as in cakes, macaroons, meringue, etc.). Their ease of digestion and high content of tissue-building elements make them a valuable food for **growing children** and for **convalescents** or any other adults whose nutritive condition needs building up.

Our **consumption** of eggs in 1945 was about 7½ eggs per week for each person in the country, of course including those used in home cooking and in commercial bakery products. Egg consumption in rural districts is generally higher than in cities and those with liberal incomes can afford to buy more of this moderately expensive food. The Food and Nutrition Board of the National Research Council recommended at least 3–5 eggs per week in their pattern for an adequate diet.

Too high a consumption of eggs is not to be recommended, especially for older persons, because of their high content of cholesterol, a fat-like substance normally present in the blood. A high intake of cholesterol may be a liability rather than an asset for persons "over forty." Although eggs are a valuable food and useful in cookery, it would seem that our present AVERAGE consumption of eggs is high enough. Of course, some individuals may be eating too many and others not getting enough for the best standards of nutrition.

Other Foods Rich in Animal Protein. It is only necessary to remind the reader that all so-called "made dishes," which contain a good deal of meat, eggs, milk or cheese, introduce a considerable amount of animal protein into the diet. Such dishes include not only all warmed-over meat dishes and those where meat is used to lend flavor to rice, macaroni, etc., but also ice cream, custards and puddings. Gelatin is likewise an animal protein and, though itself incomplete, it can be advantageously used along with some of the complete proteins. The jellies made from it ordinarily

[5] György, Rose, Eakin, Snell, and Williams, R. J., Science, v. 93, p. 447, 1941.
[6] Sydenstricker *et al.*, Science, v. 95, p. 176, 1942.

contain a large amount of water to a very small amount of gelatin, as even a 1 per cent solution of gelatin will jelly. Although they are thus low in nutritive value, such dishes make pleasing light desserts.

Vegetable Proteins and Vegetarian Diets. The **legumes** and **nuts** are the vegetable foods richest in protein, and the amounts which they contain compare favorably with the protein content of meats. Although a goodly number of the vegetable foods contain incomplete proteins, some have proteins of high quality. Most of the nuts furnish complete proteins but the proteins of the legumes, as a rule, are not of so high a quality nor so well utilized as those of the animal foods. Among the legumes, only the peanut, soybean and pea have proteins which are adequate for both maintenance and growth.

The lower **digestibility** of dried legumes, especially beans, seems to be largely due to the fibrous substances (hemicelluloses), which are present in them (especially in the skins) and which are likely to ferment and give rise to distressing gases. If they are thoroughly cooked to soften the fiber, and then put through a strainer to remove the skins, they are much more easily and completely digested. Nuts are usually eaten without cooking, but their texture is such that the digestive juices cannot penetrate them unless well chewed or ground, while the large amount of fat which they contain slows down digestion considerably if they are eaten in quantity. They should be taken in small amounts as part of a meal and along with some food low in fat.[7] The fact that whole peanuts often disagree with children, while peanut butter eaten on bread does not, well illustrates the dietary precautions necessary to make nuts a wholesome food.

Both nuts and legumes are economical foods, in fact the dried legumes are about the cheapest source of protein. As the legumes can be eaten in larger quantities than nuts, they can be made to furnish more significant amounts of protein in the diet, though nuts are attractive for flavor. Whole soybeans require long cooking and most persons do not find them an acceptable food, but soybean flour, either alone or mixed with wheat flour in bread or muffins will reinforce other proteins in the diet. Peanut flour is also useful in the same way. Nuts, legumes and cereals[8] are the chief sources of protein in the "vegetarian" diet, though vegetables also contribute lesser amounts.

[7] Note that these are the same precautions given on p. 73 for the use of cheese, which is also a close-textured food, rich in fat and protein.

[8] The cereals are a considerable source of protein in the vegetarian diet (see Table V, p. 50), in fact even in a non-vegetarian diet they often furnish as much as one third of the total protein.

A diet that is ENTIRELY from vegetable foods will generally be relatively low in protein and, unless the foods are carefully chosen, it may provide less than optimum amounts of certain mineral elements and vitamins, notably calcium and the vitamins carried by animal fats. These deficiencies can be made up by eating leafy vegetables, but "greens" are such an unconcentrated food that it is difficult for man to eat a large enough bulk of them to secure his need for these food elements entirely from this source. Hence, most so-called vegetarian diets include some animal foods, such as milk, cheese, butter and eggs, which add high quality proteins, calcium and fat-soluble A in concentrated form and supplement the deficiencies of nuts, legumes and cereals in these respects. They also serve to make the diet more palatable and enable one to satisfy body needs on a smaller bulk than when only vegetable foods are taken.

The special merits of a diet made up wholly or in large part from vegetable foods, lie chiefly in the fact that its moderate protein content, accompanied by large amounts of carbohydrate and indigestible fiber, tend to keep down putrefaction and promote hygienic conditions in the intestine. In addition, if well chosen, such a diet will promote health by providing liberal mineral elements and vitamins. The same results can be obtained when moderate amounts of meat and eggs are taken PROVIDED vegetables, fruits, cereals and milk make up the bulk of the diet. While there is no necessity to confine oneself SOLELY to foods of vegetable origin, people who have been or are heavy eaters of protein-rich animal foods, especially of meats, may find subsistence on a vegetarian diet (plus milk) from time to time beneficial as a remedial measure.

Cooking Protein-rich Foods. A few words of caution concerning the cooking of protein-rich foods are needed. We have pointed out that starchy foods are made more digestible by cooking, while fats are little changed by cooking processes unless the heat applied is sufficiently high to chemically decompose the fat. Protein, however, is immediately slightly altered chemically by heat so that it **coagulates,** and if a high temperature is applied for any length of time, the coagulated protein takes on a tough and leathery consistency which makes it more difficult to digest. Hence the main principle to be observed in preparing protein-rich food is that of a relatively **slow cooking at lower temperatures.** The leathery egg white, the stringy cheese dish and the curdled custard are all too familiar examples of protein foods where the temperature has been allowed to get too high in cooking. Contrast them with the smooth and tender consistency obtained when special precautions have been taken to keep the temperature low in

cooking as follows: putting eggs in boiling water and setting on back of stove to cook slowly, cooking cheese dish in double boiler, setting custard (or cheese dish) in pan of water when cooking in oven.

Precautions are also needed sometimes to prevent the development of a hard texture by DRYING OUT during cooking, *e. g.*, basting meats with water (and fat) while roasting or baking in oven, and a tight cover on cooking vessel to prevent the escape of steam during braising or stewing. The pressure cooker has been very useful both in preserving good texture and flavor and in shortening the cooking time required to soften connective tissue in tougher cuts of meat.

In general, too great heat may decrease the biological value of some proteins but moderate heat will increase, decrease or have no effect on this factor, depending on the protein. Digestibility of some protein-rich foods (such as legumes) is increased by proper cooking. Rapid cooking and cooking with air excluded mean less loss of vitamins. Frozen meats should be cooked immediately after thawing.

Dietary Rules for Protein-rich Foods

1. USE THESE FOODS IN MODERATE AMOUNTS. A medium-sized serving of ONE protein-rich food (not including milk) in each meal will provide enough protein, along with that contained in smaller quantities in other foods.

2. Use both animal and vegetable foods in the diet and get your protein supply from as wide a variety of sources as possible, since in this event the proteins will supplement each other and any deficiency of essential amino acids will be avoided.

3. For growing children, the protein supply should be more liberal and about $\frac{2}{3}$ of it may well come from foods which furnish complete proteins (notably milk and eggs).

QUESTIONS AND PROBLEMS

1. How do the properties of proteins differ from those of fats and carbohydrates? What elements are found in fats and carbohydrates? in proteins? Why is it essential to have protein in the diet? Why is a liberal amount of protein necessary for growing children? Where is protein found in nature? in the human body? Name ten foods that are good sources of protein.

2. What are the "building stones" of the proteins? Define an amino acid. How many amino acids have been found in proteins? How many

amino acids are present in most proteins? How many amino acids are "essential" in the sense that they must be furnished preformed in the food? What is a complete protein? an incomplete protein? a protein of high quality or high biological value? Are incomplete proteins of any use to the body and why?

3. Name five foods that contain an incomplete protein, either alone or along with some complete protein; name five foods that contain only complete or high quality proteins. What combinations of these foods could you make in which the proteins of one would supplement those of another in amino acid make-up, so that the mixture would be efficient in promoting growth?

4. In regard to the following statements, tell which are true, which are false, and why:

Meats are a good food.
Meats are acid-forming; eggs and bread are not acid-forming.
Pork is less readily digested than other meats.
Meat is lacking in minerals and vitamins.
Beans are not a perfect substitute for meat.
Egg proteins are not of as high quality as those of meat.
Eggs are rich in iron and vitamin A, but contain no vitamin C.
It is possible to have an entirely satisfactory diet from vegetable sources, without any animal protein.

5. An average serving of flesh food (meat, fish or poultry) will furnish approximately 20 grams (15–25) of protein. From the following figures, compute the amount of each of the foods listed that would be required to provide 20 grams of protein or about that in a serving of most meats.

Weight, gm.	Food.	Protein, gm.
50	Egg, 1	6.4
240	Milk, ½ pint	8.2
15	Peanut butter, 1 tablespoonful	3.9
30	Soybeans, dried, ½ cup cooked	10.5
100	Beans, canned, without pork, ½ cup	6.0
100	Peas, canned, green, ½ cup	5.4

At current prices, which of these foods is the most economical source of protein? Which furnishes the best quality protein?

6. Which of the following foods gives the greatest return in protein and food energy for the same amount of feed, judging by the figures given be-

low? An acre of cultivated farm land yields crops which, when fed to animals, give the following returns in human food:

	Protein, lbs.	Food energy, calories
Milk	289	711,750
Beef	74	130,000
Mutton	59	137,295
Poultry and eggs	110	148,675

7. What are the special advantages and disadvantages of each of the following foods: shellfish, organ meats, pork, poultry, fish?

8. What are the effects of heat on proteins? Are raw eggs more wholesome or more easily digested than cooked eggs? What effect does cooking have on the vitamins in meats? Would you think that the loss of B vitamins would be greatest in stewing, broiling, frying, or roasting? What precautions should be observed in cooking protein-rich foods, and why? What nutrients from meat are extracted in soups?

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CHAPTER 5

MILK AND MILK PRODUCTS

It is usual to treat dairy products as a separate food group, rather than with protein-rich foods, since they contribute so many nutritive essentials other than protein. Although not high in protein, their proteins are of such excellent quality and, when taken in considerable amounts, they add such quantities of protein to the diet that they are valuable protein foods. In addition, milk and its products other than butter furnish minerals and vitamins in well-balanced proportions. Dairy products other than butter include milk (fresh, dried or evaporated), thin cream, cheeses and ice creams.

Milk. Milk is almost a perfect food, which after all is what might be expected since its sole function in nature is to serve as food for young animals. The milk of each species is especially adapted to meet the needs of the young of that species. Milk is so important for and well adapted to meet the needs of infants and growing children that it should form the bulk of the food in infancy and serve as the foundation of the diet throughout the growth period—at least up to eighteen, and better until twenty-two years of age. On account of its high content of water (87 per cent), it is too bulky to be the sole food of adults, but no other food supplements the deficiencies of certain foods so well or reinforces the diet at so many points.

In order to emphasize what a well-balanced food milk is and how many of the food essentials it provides, we are giving figures below which show the approximate composition of cow's milk. Its exact composition varies with the breed of the animal, its feed, the season, the conditions of milking, etc.

Approximate Average Composition of Cow's Milk

	Per cent
Water	87.0
Protein	3.5
Fat	3.9
Milk sugar	4.9
Mineral salts	0.7

The 13 per cent of solids which milk contains is fairly evenly distributed between proteins, fats and carbohydrates, and these foodstuffs supply considerable energy to the body. Because it does not require chewing, some persons do not appreciate that it is a real fuel food. A quart of milk will supply nearly $\frac{3}{4}$ of the energy required daily by a one-year-old child and about $\frac{1}{4}$ as much as is needed by a sedentary man. The fat, being soft and in a finely divided or emulsified condition (see Fig. 4, p. 31), is especially easily digested.[1] The carbohydrate, lactose or milk sugar, does not ferment or cause digestive disturbances as other sugars may do.

Since one of the most important functions of milk in the diet is to supply protein, we will give special consideration here to its protein content. When taken under normal conditions, its proteins are more completely digested and absorbed (97–98 per cent) than those of any other food. Moreover, milk proteins are so rich in those essential amino acids required for tissue building that they are more efficient in promoting growth than any other food proteins (except those in eggs). For these reasons, we say they are proteins of particularly HIGH QUALITY. They also supplement the incomplete proteins found in the grains better than any other food proteins. Lastly milk is a fairly economical source of protein. The cereals and legumes furnish cheaper protein but their proteins are not of as high quality as those of the animal foods. When we consider ease and completeness of digestion, quality of the protein, and other valuable food constituents purchased along with it, milk is unexcelled as a protein-bearing food.

Milk is also a very valuable food by reason of the mineral salts that it supplies, especially those elements so much needed by the young in building bones and teeth, namely calcium and phosphorus. A quart of milk will furnish enough calcium to meet the total daily requirement of a child, and a pint will provide 72 per cent of the daily allowance for an adult. No other food equals milk as a source of calcium. Milk is rather low in iron and copper, although its iron is well utilized.

As to its vitamin content, milk contains all of the known vitamins and its contribution of riboflavin (vitamin B_2) is almost as outstanding as that of calcium among the minerals. It has been said that, although each of the vitamins may be found in higher concentration in some other food or foods, it is doubtful if any other food furnishes so many of these essential substances in so well-balanced proportions as does milk. Vitamin C (ascorbic acid) is rather low, and some of it is destroyed if milk is heated or

[1] In **homogenized milk** the fat is broken up into even finer droplets by being forced through small holes; in fact it is so finely divided that cream will not separate on standing.

exposed to light. Its content of fat-soluble vitamins A and D is variable. It is a fairly dependable source of the B-complex vitamins, especially of riboflavin. A pint of milk will furnish 15 per cent of the vitamin A, 15 per cent of the vitamin B_1 (thiamine) and 52 per cent of the vitamin B_2 (riboflavin) recommended as the daily allowance for a moderately active woman or a sedentary man.

The AVERAGE milk consumption in the United States, including that used in cooking, is estimated as a little over one pint per person per day. Some children get more than this amount, but many adults take very little milk as such. Milk production and consumption has increased in this country in recent years. From 1924 to 1943 inclusive (20 years) there was an increase of 20 per cent in the number of milk cows and of 36 per cent in the amount of milk produced. Yet it is probably safe to say that a further building up of the dairy industry would be of service both to the health and economic condition of the country. "The dairy cow economically converts pasture grasses, dry and succulent roughage, and the by-products of many different kinds of grain into milk, that most excellent food for man."[2] Both for amount of food consumed and man-hours of labor, dairy cattle have been found to return at least two to three times more food energy and protein in edible products than beef cattle or sheep. Egg and poultry meat production is intermediate in efficiency between beef and milk production.

Statistics of the amount of milk received by the large cities would indicate that in many cities the amount used averages less than a pint for each individual daily. Milk consumption is higher in rural districts than in the cities and in high income than low income groups. In many portions of the southern states fresh milk is hard to get and spoils quickly so that little of it is used. Sir John Orr in 1935 found an average milk consumption in Great Britain of only 0.44 pint per person per day, but this has since been increased by 50 per cent.

Contrast these figures for milk consumed with the amount agreed upon as desirable and almost necessary for an optimum state of nutrition. Experimental studies on children from three to thirteen years of age[3] have established scientifically, what was well recognized empirically before, namely that children of these ages must receive a full quart of milk per day in order to insure the best growth and development. The quantity generally recommended for the adult has been "at least a pint per day." Sherman found[4] with experimental animals that the addition of more milk

[2] Yearbook of U. S. Dept. Agriculture, 1922, p. 281.

[3] Sherman and Hawley: J. Biol. Chem., v. 53, pp. 375–99, 1922.

[4] Sherman and Campbell: J. Biol. Chem., v. 60, pp. 5–15, 1924; also J. Nutrition, v. 10, pp. 363–371, 1935.

to a diet already adequate according to current standards exerted a decidedly favorable influence upon the nutritive condition of the animals in the following ways:

(1) Greatly favored growth and development throughout youth.
(2) Conferred improved health and vigor throughout adult life.
(3) Postponed old age, increasing the average life cycle by about ten per cent.

Experiments in a British school showed that the boys given an extra pint of milk daily made greater gains both in height and weight than those receiving only the usual diet of the institution, which had previously been thought to be eminently satisfactory for health and growth. Those who received additional milk also showed better muscular tone and skin condition, as well as increased keenness for work and play. Later Scottish health authorities conducted experiments in which some 20,000 school children received supplementary milk (usually $\frac{3}{4}$ pint) while about the same number of their schoolmates had no extra milk. The results showed that "the addition of milk to the diet of children has a striking effect in improving physique and general health and increasing mental alertness." Milk has been extensively given in school lunches in the United States with similar beneficial results, but usually other foods were given at the same time or the conditions were not so well controlled as in the experiments cited above.

Such experiments convince us of the unique contributions of milk in reinforcing the diet. Probably "in no other way can the food habits now prevailing be so certainly and economically improved as by a more liberal use of good milk."[5]

How to Overcome Disadvantages of Milk as a Food. All protein foods require **special handling and refrigeration**[6] to keep them from putrefying and milk, in addition to putrefactive bacteria, contains the lactic acid producing organisms which, if allowed to multiply, will cause it to "sour." Sour milk will not putrefy because the lactic acid present keeps the putrefactive organisms from developing.

The **canned milks** meet the need for a concentrated, preserved milk which is economical to transport, of excellent keeping qualities, and conserves the surplus from the season of largest milk production. In all of these products much of the water is removed by evaporation at fairly low

[5] Sherman, H. C.: FOOD PRODUCTS, 4th ed., The Macmillan Company, p. 84, 1948.

[6] The precautions taken to prevent contamination of milk and to keep bacteria from multiplying in its production, marketing and storage are familiar to most persons and space does not permit including description of them here. Dept. of Public Health regulations safeguard most city milk supplies but pasteurization (a prolonged mild heating which destroys disease-producing bacteria) is the surest way to prevent milk-borne diseases. The housewife must do her part by keeping milk in closed containers and well refrigerated in the household.

TABLE VII. MILK AS A FOOD

Advantages.	Objections.	Objection met by:
1. Very completely and easily digested form of body FUEL.	1. Presence of disease BACTERIA and growth of organisms normally present may render it unfit for food unless precautions are taken.	1. Health inspections. Care and cleanliness in handling. Pasteurization. Refrigeration. Manufacture of canned milks.
2. Supplies PROTEIN of highest quality for promoting growth and for supplementing deficient proteins in other foods.	2. High WATER content makes it a bulky food, expensive to transport and hard to keep.	2. Production of evaporated and dried milks.
3. Furnishes MINERAL SALTS needed for tissue building and regulating body processes.	3. CURD formed by RAW milk in stomach sometimes disagrees with those who have a feeble digestion or sensitive intestine.	3. Use of milk in cooking instead of as beverage, or of other forms of heat-treated milk, *e. g.*, boiled or evaporated milk.
4. Is an excellent source of VITAMINS A and B_2 or riboflavin, and a fair source of vitamin B_1 (thiamine) and other B-complex vitamins.	4. Milk may be CONSTIPATING to some.	4. Increased use of fruits, vegetables and whole grain cereals, also other hygienic measures.
	5. Is POOR IN IRON and may be rather low in vitamins C and D.	5. Inclusion of some foods rich in these substances in the diet.

temperatures in a partial vacuum. They owe their keeping qualities to the following facts:

Dried milk powders.....keep because of very low moisture content (only 3.5 per cent water)

Condensed milks.....keep because of sugar added (about 50 per cent of final product)

Evaporated milks.....keep because sterilized[7] in sealed can—no sugar added

[7] To sterilize means to heat to a sufficiently high temperature so that all germs or bacteria present are killed. Even the cleanest milk, such as "certified milk," contains from 5000 to 50,000 bacteria per teaspoonful. While these bacteria are not necessarily harmful, they will cause spoilage of the milk unless killed by heat or otherwise prevented from multiplying.

Wisconsin milk in canned form can be sold to the Florida housewife for less than the cost of fresh milk in that state. Canned milks should thus be a considerable factor in increasing the consumption of milk in sections where it has been expensive and difficult to obtain. They are also used in INFANT FEEDING[8] and in the manufacture of ice cream, candy and similar products.

Difficulty in **digesting raw milk** is chiefly confined to young infants and to adults in whom digestion is impaired. In spite of any ideas he may have to the contrary, the normal individual will digest raw milk very completely, even though in some persons its digestion may be delayed until it reaches the intestine rather than taking place in the stomach. Milk curdles or coagulates almost the instant it is introduced into the stomach, due to the high acidity of the gastric juice and to the presence of an enzyme,[9] rennin. This curd formation is probably beneficial, as the milk would leave the stomach too rapidly if it remained in fluid form. The solid curd formed resembles that formed through the action of lactic acid when milk sours.

If large, tough or dense curds are formed, they will be digested more slowly and will remain longer in the stomach than a finer, softer curd would. Raw cow's milk forms a more solid and tougher curd than human milk or cow's milk which has been heated some time (see Fig. 10). This is one of the important reasons why mother's milk is better adapted to the delicate digestion of infants than cow's milk. Heat-treated cow's milk, such as evaporated milk, forms a fine, porous, soft curd similar to that of human milk. Hence, it not only is especially readily digested by infants with normal digestive powers, but can be taken by those infants with weak digestion who are unable to handle raw cow's milk in any form.

Adults, who for any reason find raw milk difficult to digest, can usually take heat-treated milks, such as boiled milk, milk used in cooking (cus-

[8] Both dried and evaporated milks are successfully used in feeding infants. The fat in evaporated milk is broken up into particles even finer than those present in fresh milk so it is very readily digested, and the fact that no sugar is added makes it a better food for infant feeding than condensed milk. Of special importance is the fact that the heat treatment it receives makes it form a curd more suited to the digestion of infants (see Fig. 10, p. 71).

[9] An ENZYME is an organic ferment formed by a living cell, which brings about some chemical change. The enzyme rennin is formed in the cells of the stomach lining, and the use of rennin (from calves' stomachs) to coagulate milk in making junket and also in cheese-making illustrates what the coagulation of milk is like which takes place normally in the human stomach through the action of this enzyme. The presence of hydrochloric acid in the stomach also favors the formation of milk curd. Heating to boiling temperature will destroy any enzyme, cold retards its action, and the presence of acid or alkali may either retard or favor the action depending on the particular enzyme concerned.

tards, soups, etc.), malted milk drinks, and evaporated or dried milk. Such individuals include those who normally are unable to digest the larger, tougher curd of raw milk well, those in whom a sensitive intestine (either natural or acquired as a result of diarrhea, colitis or spastic constipation) is irritated by such curds, and those in whom digestion is weakened by illness or old age. Milk loses a little of its nutritive value in the process of heating; from 10–30 per cent of the vitamin B_1 and 20–50 per cent of the vitamin C may be destroyed (lower losses for brief heating as in pasteurization, higher figures for longer heating, especially if exposed to air).

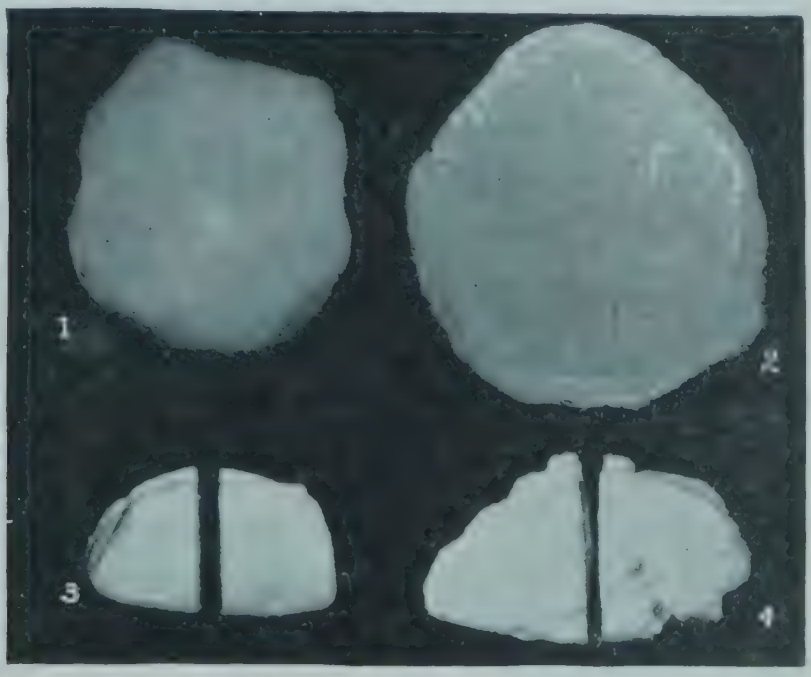


Fig. 10. Curds obtained by coagulating different kinds of milk with acid and the enzyme from gastric juice: 1, human milk; 2, evaporated cow's milk plus water; 3, raw cow's milk; 4, cow's milk boiled only one minute. The curds in (1) and (2) are about the consistency of cooked oatmeal; those in (3) and (4) are tougher and more solid, so that they can be cut with a knife. (Rice, "Archives of Pediatrics.")

A few persons are **sensitized** to milk protein so that they develop distressing symptoms when even small amounts of milk in any form are included in the diet. Such cases are not too common and the nature of the difficulty should be determined by a physician. Unfortunately such a difficulty (called an **allergy** for milk) is most apt to occur in young children. In these cases, it will be necessary to omit milk entirely, at least for a time, though sometimes the individual may respond to treatment so as to be desensitized and be able to take it later. Eggs are a fairly good food substitute for milk (see p. 57). Soybean milk (a suspension of

soybean powder in water) may also be used by children who have an allergy for milk. Some individuals who are sensitized to raw milk can take heat-treated milks, such as boiled, evaporated, or dried milk, without any reaction.

Whether or not milk has any **constipating** influence is a debatable question. Any specific constipating effect it may have is commonly supposed to be limited to boiled milk, which normally leaves little residue in the intestine. Such an influence should be readily overcome by taking sufficient high-residue foods, such as fruit, vegetables, and whole grain foods, provided the other bodily conditions are favorable for good intestinal action. The idea that milk is a fattening food has no foundation in fact. It is no more nor less fattening than any other food which supplies the same amount of fuel to the body.

Lastly it should be remembered that milk is almost but not QUITE a complete food, as it is rather **low in iron** and may also be **poor in vitamins C and D.**[10] Hence it is not suitable for use as the SOLE food over PROLONGED periods. The infant comes into the world with an extra store of iron in its own body, usually enough to last until about the time of weaning. However, we take no chances on a possible shortage of iron for the baby while it is being fed almost entirely on milk, but begin to give it egg yolk, a food especially rich in both iron and vitamins, at the age of a few months. It is likewise known to every intelligent mother now that an infant also needs some orange or tomato juice and cod liver oil to supply the vitamins C and D which may be supplied only in small amounts by milk. Most babies also get some reinforced or restored cereal, such as Pablum, which is high in vitamin B_1 (thiamine), thus supplementing the B_1 content of milk to assure better growth. If such supplementary foods are not given, serious nutritive disorders may develop on an exclusive milk diet.

The advantages and disadvantages of milk as a food are summarized in Table VII on p. 69.

Cheese. Cheese is a CONCENTRATED product made from milk and is one of the earliest ways devised for preserving the food constituents of milk. It is made by compressing the curd, obtained when milk is coagulated by rennin, and allowing it to "ripen" through the action of microorganisms. The organisms usually responsible for this ripening are lactic acid bacteria and molds; they partially digest the protein and develop the flavors peculiar to the different kinds of cheese.

[10] VITAMIN D MILK is milk whose normal low content of this vitamin has been increased by one of three methods—(1) exposure to ultra-violet light, (2) feeding the cows yeast that has been exposed to ultra-violet light (irradiated), (3) addition of a fat-free tasteless extract from cod liver oil. A quart of vitamin D milk will protect a child against rickets, a disease caused by lack of this vitamin.

Cheese is not so popular a food in the United States as it deserves to be. In Europe it is an important article of the diet in many countries, and the different varieties are highly prized for their characteristic flavors. Small towns in France have several shops devoted exclusively to the sale of cheeses (fromageries), where even the poorer classes have a choice of a dozen or more varieties. In this country the total **consumption** of cheese in 1945 was 5.7 lbs. per person, and three fourths of all that is used is of the cheddar type popularly known as American cheese. Cottage cheese, which is not allowed to ripen, and cream cheese, a soft cheese made from cream instead of milk, are in fairly common use. The consumption of cottage cheese tripled between 1918 and 1930. We also use small amounts of imported cheeses or those with similar flavor now manufactured in this country.

Cheese contains practically all of the constituents of the milk except some of the soluble protein (lactalbumin), salts and milk sugar which are lost in the whey. Its **composition** may be said to approximate $\frac{1}{3}$ water, $\frac{1}{3}$ fat, and $\frac{1}{4}$ protein, provided it is made from whole milk. Very hard cheeses contain less water than this and soft cheeses more. Cottage cheese is almost fat-free, while cream cheeses are high in fat content. Part of the ash may be due to added salt. Cheese is not only an excellent source of PROTEIN but is a concentrated FUEL food, besides containing most of the calcium, phosphorus, iron and vitamins of the milk. Cottage cheese contains only $\frac{1}{10}$ as much calcium as American cheese, chiefly due to its higher moisture content.

Because of its firm texture and high fat content, cheese slows down **digestion** in the stomach and is itself digested mainly in the intestine. Experiments have shown that it is over 95 per cent digested and absorbed under ordinary circumstances. Digestive distress following the eating of cheese is usually due either to eating too large quantities of it at one time or to taking it at an unsuitable time (with an otherwise heavy meal, at bedtime, etc.). It should be taken in moderate quantities along with some fat-poor food such as bread, and should be well chewed or finely grated. The highly flavored cheeses should be used only in small quantities. Milder and less concentrated cheeses, such as cream or cottage cheese, are those best suited to the digestion of children or invalids, although small amounts of other cheeses used to flavor some dish such as soufflé, spaghetti, or toast may also be digested without difficulty. Used with such dietary precautions cheese forms a valuable addition to the diet.

The value of cheese in the diet rests chiefly on the fact that it is an **economical** source of **protein and fuel,** while its flavor makes it more acceptable to many people as a **meat substitute** than bland protein foods

like milk and eggs. It provides about twice as much food value for the money as meat and is also a more economical food than eggs. Because it is such a concentrated food, it should either be made the main dish of the meal or taken in small amounts at the end of a meal, when its flavor and satiety value are especially appreciated. One of Brillat-Savarin's witty comments on food[11] is, "Dessert without cheese is like a pretty girl with only one eye." Small amounts of cheese also add a pleasing flavor and fuel value to salads and vegetables. When used in larger quantities as a meat substitute it is best combined (diluted) with some bland starchy food such as bread, macaroni, spaghetti, rice or potato. If cooked, it must not be over-heated or it will have a leathery texture and be much harder to digest. As it is really best eaten without cooking, a more liberal use of cheese would make for ease in preparing meals.

Ice Cream. A considerable quantity of the milk produced in the United States goes into the manufacture of ice cream, for without question we consume more ice cream than any other nation. British and Europeans take most of their nonfluid milk in the form of cheese, although ice cream is becoming more popular in England; Americans eat little cheese but much ice cream. Not only is ice cream a common dessert in homes and restaurants but large quantities are dispensed at soda fountains, both as such and in various "frosted" drinks. Perhaps such between-meal snacks may spoil the appetite for regular meals, but growing youngsters can get away with a lot of food and may get a good deal of extra milk in this way. For ice cream of course is made from a milk base, with sugar and fruit or fruit flavorings added, sometimes with small amounts of gelatin or egg for thickening; cream or chocolate may be included and thus raise the fat content of ice cream above that of plain milk.

The average commercial ice cream has about 3 times the fuel value of milk; its water content (62%) is somewhat lower and its protein content (4%) only slightly higher than that of fluid milk. While ice creams vary considerably, they range from about 9–12 per cent fat and 19–23 per cent carbohydrate (sugar). They carry the same minerals and vitamins, and in about the same concentration, as in milk. Thus ice cream supplies high quality proteins, and is especially rich in calcium, phosphorus and riboflavin (vitamin B_2). The vitamins are not injured by freezing. Plain ice cream carries only a trace of vitamin C but those with fresh fruit added (and fruit ices or sherbets) will provide some of this vitamin. Milk sherbets have about the same fuel value (calories) as plain ice cream, a fact that is frequently overlooked by persons who are reducing weight. The fat in

[11] See explanatory reference to this author on p. 296.

ice cream is in the same finely divided (emulsified) state and carries the fat-soluble vitamin A as in milk. Ice cream is thus an easily digested food and is useful in introducing all the valuable ingredients of milk into the diet in well-liked form.

Cream. Cream contains more milk fat and fat-soluble vitamins than does whole milk. Light cream (20% fat) has 3 times the fuel value and 5 times the vitamin A content of an equal amount of fresh whole milk, yet it carries only a little less of the B-complex vitamins and calcium than milk: heavy cream (35% fat) has 5 times as great fuel value and 10 times as much vitamin A as milk, while it still contains appreciable quantities of calcium and B vitamins. As the fat content goes up the protein content goes down, so that milk is a much better purveyor of the valuable milk proteins than cream. However, especially for one who will not drink milk, the use of thin cream or top milk on cereals, puddings, etc., is a good way of obtaining some of the essential nutrients for which milk is valued.

QUESTIONS AND PROBLEMS

1. Which of these statements are true and which false, and why?
   Milk is an important source of complete proteins.
   Milk is a perfect food.
   Milk is constipating.
   Milk is fattening.
   Milk carries disease germs.
   Cows' milk is less easily digested by babies than mother's milk.
   It is difficult to get enough calcium in a diet without milk.

2. The recommended daily allowance of calcium for a child (up to 10 yrs.) is 1 gram or 1000 milligrams. One quart of milk will provide the full day's allowance, or 1.15 gm. calcium. What quantities and combinations of the following foods would be required to furnish HALF the day's allowance, or 500 milligrams calcium?

Kale, ½ cup, cooked	225	mg. calcium
Broccoli, ½ cup, cooked	130	" "
Bread, 100% whole wheat, 1 slice	17	" "
Cereal, whole wheat, ¾ cup, cooked	11	" "
Egg, one	27	" "

3. It is recommended that a 2-year-old child should have daily 1200 calories and 40 grams protein. What per cent of this will be furnished by a quart of milk which furnishes 670 calories and 34 grams of protein?

4. The recommended daily allowance of calcium for an adult is 1.0 gm. or 1000 mg. What percentage of this will 1 pint of milk furnish? From the

figures given below, calculate how much of each food would be needed to replace the pint of milk as to calcium content:

Milk, 1 pint	575	mg. calcium
Cheese, American, cheddar, 1 oz.	247	" "
Ice cream, $\frac{1}{4}$ quart	188	" "
Cream, light (20% fat), $\frac{1}{2}$ cup	97	" "

5. What nutritive substances other than calcium and proteins does milk contain? In which vitamin or vitamins is milk especially rich? Of what other vitamins is it a good source? Of which vitamins is it a poor source? Is there any mineral in which milk is relatively poor, and if so, what? Why are babies given orange juice, cod liver oil, egg yolk, cereals and green vegetables at an early age? Is pasteurized or boiled milk safe for babies, and, if so, why?

6. Name the constituents of milk that are found in concentrated form in cheese. What is the difference in composition between cheese made from full milk and that made from skim milk? between hard and soft cheese? Name three hard cheeses and three soft cheeses. Mention five ways in which cheese can be introduced into the diet.

7. What substances are added to milk in making ice cream? How do these added substances make the nutritive value of ice cream differ from that of plain fluid milk? In which ways does ice cream resemble milk in nutritive value?

8. Get current prices on fresh whole milk, 20% cream, evaporated milk, dried whole milk, and dried skim milk. Which is the cheapest form in which to buy milk fat, milk solids other than fat?

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CHAPTER 6

FRUITS AND VEGETABLES

FRUITS and vegetables have long been valued for their pleasing taste and for the variety in flavor and texture which they introduce into the diet. They have often been regarded, therefore, as luxuries rather than as essential foods. We desire to emphasize in this chapter: (1) why it is NECESSARY to include SOME of these foods in any well-balanced diet, and (2) why an ABUNDANCE of these foods makes for a diet that promotes health.

The U. S. Department of Agriculture has sponsored a grouping of fruits and vegetables which has been widely used in planning crop distribution and family diets. Their groupings are as follows:

(1) Mature legumes
(2) Potatoes and sweet potatoes
(3) Green and yellow vegetables
(4) Citrus fruits and tomatoes
(5) Other fruits and vegetables

The first two classes are fairly high in starch and hence furnish more food energy than other vegetables and the fruits: in addition, the legumes (peas, beans and lentils) carry considerable protein. Green and yellow vegetables are put in a special class because of their vitamin A value, citrus fruits and tomatoes because of their vitamin C content, and a lot of dissimilar fruits and vegetables are lumped in the final group. The writer feels that this classification may be misleading in its over-simplification and over-emphasis of certain vegetables or fruits as the chief, if not the only, source of certain nutritive essentials. For instance, all vegetables (and fruits) furnish some protein, and in general it is good quality protein. Sweet potatoes certainly qualify as a yellow vegetable and several yellow fruits also are of high vitamin A value. All fresh fruits and vegetables, except the dried legumes, contribute some vitamin C, and several vegetables have a higher content of this vitamin than citrus fruits and tomatoes. There are dissimilarities among green and yellow vegetables according as they represent different parts of the plant (leaves, growing shoots, immature flower buds or seed pods, fleshy roots, or

fruits); but the different parts of the plant usually are strikingly alike in composition, and hence in nutritive value.

So let us consider first the main contributions that fruits and vegetables make to the diet, and later study the relative composition of different parts of plants used as food. Except for the legumes, potatoes and sweet potatoes, they are rather low in energy value and protein: nutritionists urge a liberal use of fruits and vegetables because their mineral and vitamin content is needed to supplement that of other foods (chiefly grains, meats and sweets) which bulk large in most diets. The minerals we need in largest amounts are calcium, phosphorus, and iron; of these the ones most likely to be furnished in less than adequate quantities by the rest of the diet are calcium and iron, so that the contributions of these two elements by fruits and vegetables become of importance. In order to understand the importance of their vitamin contributions, we should have a little more information about vitamins.

Vitamins and How We Get Them From Vegetables and Fruits. There are two main classes of vitamins—(1) those that are soluble in, and hence carried by, fats and (2) those that are soluble in water. The best known vitamins are listed below, grouped as to whether they are fat-soluble or water-soluble:

Fat-soluble.	Water-soluble.
Vitamin A	Vitamin C or ascorbic acid
Vitamin D	Vitamin B_1 or thiamine
Vitamin E	Vitamin B_2 or riboflavin
Vitamin K	Niacin or nicotinic acid
	Other vitamins of the B-complex

Naturally the fat-soluble vitamins are found chiefly in fatty foods, such as liver, butter, egg yolk, etc. Milk and its products other than butter carry both types of vitamins, one kind in the fat globules and the other kind (water-soluble) in the watery portion. It is to animal fats that we must look for vitamin A; dairy products, meats, eggs and whole grain foods supply B-complex vitamins; none of the foods thus far studied provide any appreciable amounts of ascorbic acid or vitamin C. If vegetables and fruits are to supplement the rest of the diet in the vitamins in which it is most apt to be deficient, it is to be hoped that they would provide vitamins C and A in liberal quantities. But how can vegetables and fruits, which are almost fat-free, supply fat-soluble vitamin A? The answer is that they do not contain this vitamin AS SUCH but substances from which it can be made in the body. These substances are yellow pigments, called carotenes (because present in carrots).

Only the green and yellow vegetables (and yellow fruits) contain these substances from which vitamin A can be made and this accounts for the emphasis that nutritionists place on this class of fruits and vegetables. In yellow vegetables and fruits, such as carrots, squash, pumpkin, sweet potatoes, apricots, cantaloupe, and yellow peaches, the presence of these pigments is apparent and the depth of the yellow or orange color is an index of their relative "vitamin A value." In green vegetables, the yellow pigment is there but its color is covered up by the green pigment, chlorophyll, which is also present in abundant quantities. It is incorrect to say that the green and yellow vegetables contain vitamin A but, since they carry a substance or substances from which the body can make this vitamin, we speak of them as having VITAMIN A VALUE. Fortunately, green and yellow vegetables (and yellow fruits) are often quite rich in vitamin A value, so that more than half of the vitamin A available to the body may come from these sources. The remainder we get, in preformed condition, mostly from milk, butter, and eggs.

We are almost completely dependent on fruits and vegetables for our intake of vitamin C or ascorbic acid. All plants form ascorbic acid and it is found in all parts of the plant except seeds. However there are wide differences in the amount of this vitamin present in different fruits and vegetables, and even in the same species grown under different conditions. Also, since this vitamin is easily destroyed by oxidation, much of the vitamin C in vegetables and fruits may be lost during storage, canning, or cooking. And because it is water-soluble, a considerable quantity may be dissolved in the cooking water. Although cooked and canned foods provide minor amounts of ascorbic acid, the major portion of our supply will come from FRESH, RAW fruits and vegetables. Cooked potatoes, eaten in bulk, may contribute considerable vitamin C in the diet; broccoli and leafy vegetables are very high in ascorbic acid and even after cooking will probably be richer in it than orange juice. Strawberries have a higher vitamin C content than oranges, other berries and pineapple have about the same level as tomatoes. Raw vegetables, especially green, leafy ones, are good sources of this vitamin, and all raw fruits or fruit juices contribute some. It should be emphasized that citrus fruits and tomatoes are dependable and fairly concentrated sources of vitamin C, which are well liked and widely used, but other fruits and vegetables may contribute decidedly to our supply, especially if eaten in quantity.

The water-soluble B-complex vitamins are found in plants, though usually in low concentration since the edible parts of the plant are 75 to 90 per cent water. Thiamine in many vegetables and fruits is present only to

the extent of one part of the vitamin in a million parts by weight of the food. Legumes and cereals are an exception, as plants seem to store or concentrate this vitamin in seeds, along with other vitamins of the B-complex like niacin and riboflavin. The two latter are also fairly abundant in green leaves. The content of B vitamins in vegetables is further lowered by losses in cooking or in solution in the cooking water. On an average, three servings of cooked vegetables and two servings of raw fruit would supply only about one fifth of the daily allowances of thiamine and riboflavin, and much less than this proportion of the needed niacin. While we must get the bulk of these vitamins from other foods (whole grain cereals, legumes and nuts, meats, eggs and milk), the extra amounts that we can obtain from a liberal use of vegetables and fruits will be helpful in augmenting our intake of B-complex vitamins.

Lastly, why is it important to get a liberal supply of all of the essential vitamins? We know that vitamins function as body regulators, that is, they lubricate the various parts of the body mechanism so that it runs smoothly. Later we will study the individual vitamins and the tasks of body up-keep for which each is responsible. Just now what we want to know is why the extra vitamins that we would get by consuming more fruits and vegetables are a real asset. A certain minimum intake of each vitamin needed by man is required for normal growth of children and health of adults, for vitamins promote growth, stimulate appetite, maintain proper functioning of the digestive tract, and help in the assimilation of foodstuffs. They play an important part in the life processes of body cells and tissues, thus helping to keep them healthy and resistant to infections. The ordinary diet may furnish enough vitamins to avoid nutritional disaster, but it has been established by experiment that from two to four times the MINIMUM requirement will often bring dividends in better growth for children and better health for persons who are not sick but are "below par" in many ways. The extra quota of vitamins that is provided by the LIBERAL use of vegetables and fruits, especially those that are comparatively rich in certain vitamins, may be sufficient to raise the total vitamin intake to the level where it will bring returns in better health.

RELATIVE COMPOSITION OF DIFFERENT PARTS OF PLANT

Leaves. These are the most active parts of a plant (except for the tips of growing shoots). In them take place the chemical transformations upon which the life of the plant depends. We are dependent entirely upon plants for taking simple substances from the air and soil and building them up into the more complex substances, carbohydrates and proteins, which we

need for food. These substances are made in the leaves of plants through the agency of sunlight and the green pigment, chlorophyll.

The leaves thus represent the chemical laboratories of the plant. They possess a skeleton or framework of fibrous, indigestible material, cellulose, which is indeed common to all the various parts of the plant. They contain practically no fat and relatively small amounts of sugar or protein, as the latter are either used up or carried in the sap to other parts of the plant almost as fast as they are formed. It is characteristic of these active parts of the plant, however, that they are RICH IN the mineral elements CALCIUM AND IRON, and also in most of the VITAMINS, especially VITAMIN A AND RIBOFLAVIN (B_2). Many of them are also high in vitamin C when fresh and uncooked.

The GREENER the leaf the more actively it functions, and so the richer it is in minerals and vitamins. The blanched inner leaves of lettuce, cabbage or celery are no richer in mineral salts and vitamins than the stalks or roots of some other plants, which are used as food.

Stalks, Flowers and Green Pods. Young shoots, with actively growing tips (such as asparagus tips) are also high in their vitamin A value and are somewhat similar in composition to leaves. The stalks, flowers and immature seed pods, as less active parts, are intermediate between the green leaves and the roots in their content of minerals and vitamins. They consist mainly of cellulose, water and a little carbohydrate, but they are fairly good sources of calcium and of most vitamins.

Roots and Tubers. In general these have a lower content of mineral elements and vitamins than the stems and leaves. The fleshy roots (such as carrot, beet and turnip) differ from the tubers (potatoes), in that the latter, being a storage part of the plant, contain considerable starch. Some of the fleshy roots like the beet and carrot have an appreciable content of sugar, however, while the sweet potato has 5–8 per cent sugar in addition to about 20 per cent of starch.

All of them are fibrous, consist of approximately 75–90 per cent water, furnish some calcium but not much iron, are fair sources of the B-complex vitamins, thiamine and riboflavin, as well as of vitamin C if not cooked too long and if eaten in quantity. The contribution of potatoes to the vitamin C content of the diet was noted above; in the average American diet they furnish about 13 per cent of the total vitamin C intake. Yellow roots and tubers like carrots and sweet potatoes, are excellent sources of vitamin A.

Seeds. Seeds are also a storage part of the plant and hence are high in starch, and they are relatively low in moisture. Most of the seeds used as food belong to the grains, which have been treated elsewhere (Chap. 2,

pp. 16–21). Those usually classed with the vegetables include the legumes (beans, soybeans, peas, lentils and cowpeas) and green corn. These are the only vegetables whose protein content is high enough to make them significant sources of this foodstuff. When fresh, their protein content ranges from 4 per cent (green corn) to 12.5 per cent (soybeans) and their carbohydrate content from about 18 to 23 per cent (except soybeans, 6%). The dried legumes, because of their low moisture content, show figures as high as 62 per cent carbohydrate and 25 per cent protein (35% for soybeans) before cooking. The quality of the legume proteins tends to be inferior to that of animal foods except for those of the peanut and soybean, which are adequate for growth. The nutritive value of legume proteins is improved by cooking.

In addition to their RICHNESS IN STARCH AND PROTEIN, this group of vegetables is characterized by being VERY HIGH in IRON, PHOSPHORUS and VITAMIN B_1 (thiamine), and they also contain a fair amount of calcium. Vitamin C in dried legumes is almost entirely destroyed by drying, storage, and the long cooking necessary for these foods. FRESH green peas, however, have a good content of vitamins A, B_1, and C. Yellow corn furnishes appreciable amounts of vitamin A, especially when used in quantity (yellow cornmeal) as in southern parts of the United States.

Fruits. In this class belong not only those foods which we usually speak of as the fruits but also the tomato, eggplant, cucumber, squash, vegetable marrow, pumpkin and all of the melons. The fruit of a plant is usually about 85–95 per cent water, which carries small amounts of sugars, organic acids and mineral salts in solution. Most of the fruits are eaten raw and hence are our best sources of vitamin C, especially citrus fruits and tomatoes. They are usually poor in vitamin A, with a few notable exceptions. Apricots, prunes, yellow peaches, avacados, cantaloupe, squash and tomatoes are good sources of vitamin A.

Fruits contain practically no fat and only small amounts of protein. Their fuel value comes chiefly from their sugar content and from the organic acids, which can be burned in the body and have a fuel value about half that of sugar. They are the least taxing of foods to the digestive organs, due to the absence of fat and to the fact that their food materials (salts, simple sugars and organic acids) are mostly ready to absorb without any digestion. Their fiber is chiefly in the seeds and skins rather than in the pulp of the fruit itself.

IMPORTANCE OF FRUITS AND VEGETABLES IN THE DIET

It should be noted that fruits and vegetables, as a group, are good or fair sources of the various mineral elements, of vitamin A (green and yel-

low ones) and B-complex vitamins, while they are our main reliance for vitamin C in the diet. Although they furnish small amounts[1] of easily assimilated energy and protein, THEIR CHIEF NUTRITIVE VALUE LIES IN THEIR BEING EXCELLENT CARRIERS OF **mineral salts and vitamins.** In addition they give needed **roughage or bulk** to the diet. In these three respects they serve to offset the influence of the foods rich in starches, fats and protein which we have been considering thus far—foods like highly milled cereals, sugar, fats and meats, which are very low in residue and poor in most salts and vitamins. Together with milk, they form a group of foods which serve to supplement the deficiencies of those foods upon which we depend for meeting our energy and protein needs. Thus, even though fruits and vegetables are expensive foods when measured by the amount of energy and protein furnished, they are cheap at any price because they are ESSENTIAL for the sake of the other food elements that they carry, which are needed to balance the diet and to make it adequate for all the needs of the body.

It may emphasize the advantages of eating a LIBERAL AMOUNT of vegetables and fruits to consider their influence in the diet from a somewhat different angle. From the standpoint of their effect on health and general well-being, we should point out their possible influence—

1. **On appetite and digestion.** Fruits are our most delicious natural food products. In form, color, aroma, flavor and texture they are highly pleasing to the senses of sight and smell, as well as to the taste. Hence they are stimulating to the appetite, and food eaten with appetite always digests better. While most of the vegetables are not as appetizing as the fruits and their qualities in this respect are often ruined by the way in which they are cooked, those that can be eaten raw in salads are pleasing in their crispness and coolness; and the cooked vegetables help to afford that variety of color, texture, form and flavor which is needed to make a meal retain its gastronomic interest throughout. One soon tires of a diet consisting entirely of soft, bland, low-residue foods, of which the "soft diet" usually prescribed for convalescents is a good example.

2. **On intestinal hygiene.** In order that the intestine shall be muscularly active and pass along the food residues fairly rapidly, it must have some bulk of material to work on, so that diets which are almost 100 per cent digested and absorbed (such as white bread, fats, meat and eggs) lead to inactivity of the intestine. Fruits and vegetables, which introduce indigestible fiber into the intestine, help to promote more rapid intestinal movements and prevent constipation.

[1] The legumes and potatoes are an exception to this general statement, since they furnish considerable energy and protein.

Fruits have a further favorable action in that the acids and salts which they contain often have a specific effect in stimulating the muscular contractions of the intestine. Thus the well-known laxative effect of grapes is largely due to the acid potassium tartrate which they contain. Eating too much of such foods may even lead to diarrhea and, naturally, they should be temporarily avoided when the intestine has become irritated, inflamed and over-active muscularly.

But the difficulty is usually in the other direction because a sedentary life and a diet of manufactured foods, from which most of the roughage has been removed, lead to sluggishness of the intestinal movements. Such a diet is apt to be low in vitamin B_1 (thiamine), a deficiency of which also leads to poor muscular tone of the intestines. Current food and health habits thus tend to favor the development of constipation, and eating a liberal amount of fruits and vegetables is one of the simplest and best ways of correcting this tendency.

3. **As body alkalinizers.** Prevalent dietary habits also frequently lead to a predominance of acid-forming foods in the diet and the **fruits and vegetables** constitute our best **base-forming foods.** Although the harmfulness of an acid-forming diet may not be fully established or may have been overemphasized, it seems extremely probable that taking at least as much of the base-forming foods as of the acid-forming foods will in the long run be advantageous for the body. Whether this is because the excess bases contributed by one type of foods combine with and neutralize the effects of the acids which arise from the other foods, or for totally different reasons, there is no doubt of the beneficial influence on health when fruits and vegetables occupy a predominating place in the diet.

Why certain foods are acid-forming and others base-forming in the body may be briefly explained as follows. After the food is digested it is absorbed into the system and carried by the blood to the tissues, where it is subjected to chemical processes which burn up (oxidize) the organic or combustible part of the food, setting free energy and heat and, leaving behind only the mineral elements or ash constituents. These mineral elements are of two kinds, acid-forming and base-forming as listed on p. 5. If more than half of the ash constituents left after a food is burned in the body belong to the base-forming column, that food will furnish to the body an excess of basic elements over acidic elements and is hence called a base-forming food. An acid-forming food is one which furnishes to the body an excess of acidic elements over basic elements after it has been burned in the tissues.

The blood and tissue fluids normally contain a slight excess of the base-

forming elements over acidic elements and the best health of the tissues is apparently at least partly dependent on maintaining this slight preponderance of bases over acids in the body—often spoken of as the "alkali reserve."[2] When acid-forming foods predominate in the diet, the body fluids do not actually become acid but some of the excess acid has to be neutralized by drawing on the "alkali reserve," so that the slight excess of base-forming elements normally maintained in the body is gradually depleted. When base-forming foods predominate in the diet, not only is there no need to draw on the "alkali reserve," but this excess of basic elements in the body is built up to such an amount as favors the best health of the tissues.

The fact that many people choose their diet chiefly from the acid-forming foods will be apparent from the general classification of foods on this basis as given below.

Acid-forming foods.	Base-forming foods.
Eggs	Most fruits
Meat, fish, and poultry (especially oysters)	Vegetables (especially legumes and white potatoes)
Breads of all kinds (both white and whole wheat)	Nuts
Cereals, pastries, puddings, etc.	Milk

It should be noted that the fruits and vegetables are our best alkalinizers. It is frequently puzzling to people how a fruit, which tastes acid and does contain acid, can be an alkalinizer in the body. This is due to the fact that the acid we taste is usually an organic acid which the body is able to oxidize or burn up as fuel in the tissues, while the rest of the fruit contains a predominance of base-forming elements, so that an alkaline ash is left in the body after the food is burned in the tissues. The completeness with which the organic acids are burned depends both upon the kind and the amount taken. Most acid fruits contain citric acid, malic acid or a mixture of the two, and these organic acids are ordinarily well oxidized in even large amounts by normal people.

Grapes, raisins and figs contain tartaric acid; cranberries, prunes and plums give rise to hippuric acid; rhubarb, spinach, chard and beet tops contain oxalic acid. Probably the body has little or no ability to oxidize these acids. Hence, taking an excess of foods which contain them, while it would not cause the tissues to become acid, would rob the body of useful basic elements, which must be paired off with the acids before they can be excreted as salts.

[2] Alkali is another term for a base, *i. e.*, a substance possessing opposite properties from the acids and able to unite with and neutralize them.

Apples, bananas, oranges, cantaloupe, raisins, the legumes and white potatoes are foods which have been found experimentally to be very efficient in reducing any slight acidity of the body which may be induced by a prolonged acidic diet (acidosis) and in building up the "alkali reserve."

4. **On general health.** VIM, VIGOR AND VITALITY seem to depend, to a considerable extent, upon having plenty of vitamins in the food. Recent experimental work has produced evidence that resistance to bacteria is directly connected with the supply of vitamins. It is noticeable that many of the people who fall an easy prey to infections are those who habitually eat a diet composed mainly of bread, sweets, meats and starchy foods—foods which are known to be low in both minerals and vitamins.

A diet poor in vitamins has also been shown to be associated with loss of appetite, as well as to lead to poor muscular tone of the intestinal wall and lowered resistance to bacteria in the mucous membranes that line the alimentary tract and respiratory passages. Vitamins probably act to protect the body from infections chiefly through keeping these mucous membranes in good condition so that bacteria are unable to gain entrance through them.

Instead of waiting to combat such troubles with concentrated forms of vitamins and salts bought at the drug store it is far better to strive to prevent them by making a practice of including in the diet an ABUNDANCE of vegetables and fruits (also milk) to act as bearers of needed mineral elements and vitamins.

FACTS ABOUT FRUITS

Since there are considerable variations in composition among fruits and vegetables, even in the same general class, it is necessary to say something about these foods on an individual basis.

Variety and Properties of Individual Fruits. In common practice the fruits used are chiefly limited to the apple, banana, orange, grapefruit, peach, pear, and a few of the berries. These are extremely palatable fruits, which are valuable adjuncts to the diet, so that their use might well be even more extensive than it is, while at the same time some of the less used fruits are introduced for the sake of variety. All fruits should be as ripe as possible when eaten, but this is especially true of apples and bananas, because when unripe they contain a good deal of starch which is gradually changed to sugar during the ripening process (see Fig. 11, p. 87). A banana is not thoroughly ripe until the skin is flecked with brown.

DRIED fruits such as dates, figs, raisins, and currants are high in fuel value, due to their low moisture content and richness in sugar. The dried

fruits are practically the only ones which carry much calcium and iron. They can be used to great advantage in cooked foods, to which they add much in flavor and nutritive value, as well as for desserts or breakfast fruit. Prunes, which belong in this same group of fruits, are good sources of

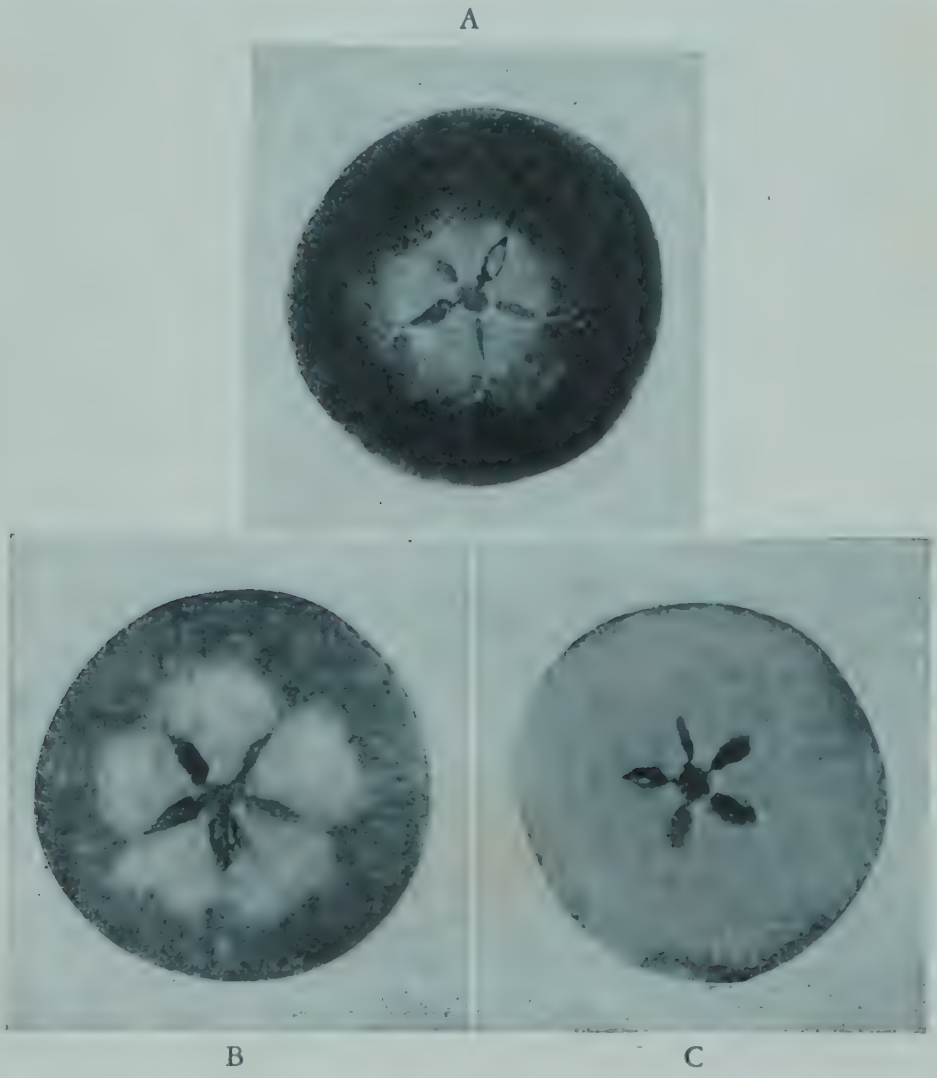


Fig. 11. Apples cut in half and stained with iodine (black) to show the decrease of starch with ripening of the apple. A and B, condition in which usually picked for market. C, thoroughly ripened apple in which nearly all the starch has been converted into sugar. (From Sherman "Food Products." By permission of The Macmillan Company, Publishers.)

iron and vitamin A and fair sources of the B vitamins, riboflavin and niacin. Dried yellow peaches give more of all of these nutritive essentials than prunes. Apricots have a delicious flavor, carry considerable amounts of iron and calcium, and are the richest fruit source of vitamin A. Their wider use should be acceptable, and in canned or dried form they are or-

dinarily not unduly expensive. While the vitamin content of canned and dried fruits may be somewhat impaired, much of it is still retained and they are valuable for other nutritive elements that they provide, as well as for use when many fresh fruits are out of season.

The FRESH fruits are rather notoriously low in mineral elements and vitamin A, but, as a rule, fair in their content of the B vitamins, and good sources of vitamin C (ascorbic acid). Few contain enough calcium and iron to be worth mentioning, though all contain small amounts of these elements so that if eaten in bulk the amount contributed may be considerable. Olives are an excellent source of iron and calcium, as well as being fairly high in fuel value on account of their fat content. Green olives have somewhat less fuel value than ripe ones, since the oil develops as the fruit ripens. Fresh apricots, pumpkins and cantaloupes are high in vitamin A value, while yellow peaches, nectarines, bananas, and certain varieties of cherries contribute lesser but noteworthy amounts. Pineapple is a fruit which might well be more extensively used, though it seems to be better digested cooked than raw. Even when canned, the content of pineapple in vitamins B_1 and C is still fairly high. If not too expensive, the numerous varieties of melons may introduce a pleasing note of change in the diet, cantaloupes being especially good as an "alkalinizer" and for their vitamin content. Grapes are not an expensive fruit, are high in sugar, and of decided laxative properties. Blueberries are also especially laxative on account of their high cellulose content.

Other less common and more expensive fruits which may be used occasionally for the sake of variety are cherries, gooseberries, loganberries and mulberries, currants, guavas, nectarines, pomegranates, persimmons, and the avocado or alligator pear. Avocados and olives belong in a separate class from the other fruits because of their high fat content (olives, 13.5–16% fat; avocados, 26% fat). The avocado is higher in food energy and vitamin A value than olives, and also has good content of thiamine, riboflavin and vitamin C. It is usually chilled as a salad fruit, and served with lemon juice since it has a bland flavor.

NUTS. These are the SEEDS of certain trees or plants, rather than true fruits. However, mention will be made of them here as vegetable products which deserve a larger place in the dietary, not only as sources of fuel and protein (see Vegetarian Diets, pp. 60–61), but because of their richness in mineral elements and the vitamins of the B-complex.

Cooking and Preserving Fruits. Cooking is not an important item with fruits because they are eaten raw to such a large extent and the process of cooking them requires little skill. They are usually cooked by stewing, which softens their fiber and renders them slightly more digestible, though

it destroys some of their content of ascorbic acid (vitamin C). This vitamin survives heating fairly well if the medium is strongly acid, as in tomatoes, raspberries and loganberries (also in pineapple). Fresh fruits are best eaten raw, and need be cooked only if slightly unripe or in canning (and then only for a short time). As the flavor and vitamin content of fruits is better conserved by short cooking, it is advisable to soften the fiber of dried fruits by long soaking followed by brief cooking, and in some cases the cooking may even be unnecessary if the soaking has been sufficiently prolonged. They should be cooked in the water in which they were soaked, having of course previously been well washed. The cooking water should be kept small enough in amount to be served with the fruit, as much of the valuable minerals and vitamins that are soluble in water, will be found in this juice. This is also true of the juices of canned fruits.

Drying is only one of several methods used to preserve fruits for use out of season. Ripe fruits are one of the most perishable of foods and must be used quickly or else carefully refrigerated. Modern methods of refrigerating in shipping have done so much in allowing fruits to be transported long distances that they are responsible for a revolution in our food supply and habits. By this means we are now able to have fresh fruits (and vegetables) all winter, and to have in common use in the temperate zone, fruits which can be grown only in tropical or semitropical climates (oranges, bananas, grapefruit, etc.). Extensive use is also made of the processes of canning and drying to preserve the excess of fruit crops in season for periods when they are either unavailable or very expensive. Commercial canning is now highly perfected and choice fruit is often selected for this purpose. There is no valid objection to "tin" cans as now used in commercial canning and their use instead of glass jars has done much to make canned fruit available at cheaper prices. Home canning is useful chiefly for the economy of preserving local crops which would otherwise be wasted. Dried fruits are the cheapest form of fruit available for winter use and may be very palatable, if a good grade product is selected and it is properly cooked. Frozen fruits have practically the same flavor and vitamin content as fresh ones, but are still fairly expensive.

It is inadvisable to have much sugar added to fruit when canned or stewed, as this makes of it almost a confection so that it sates the appetite and does not take the place in the diet which should be met by fruits, as an appetizing food of low fuel value. In jellies[3] and preserves, we have two instances where sugar is added in large amounts to keep the fruit from

[3] The property of forming a jelly is due to a substance called pectin, which is present in large amounts when the fruit is only partially ripe, and which, after boiling with sugar, coagulates to form a jelly on cooling. This substance can now be bought and added to fruits which contain too little pectin to jelly otherwise.

spoiling. They are, accordingly, high fuel foods and should be used only in small amounts as accessories, preferably at the end of a meal.

Cautions in Using Fruits

1. Do not use unripe fruit. If only slightly under-ripe, it may be rendered digestible by cooking.
2. Wash fruits that are to be eaten raw and dried fruits very thoroughly.
3. Eliminate fruits from the diet temporarily in cases of diarrhea or other types of intestinal irritation.
4. For very young children and others with a sensitive intestine, strain the fruit and use only the pulp (or juice).
5. For persons who find that certain fruits ferment and cause trouble with gas when eaten raw, use these particular fruits only in a cooked state.
6. Persons inclined to stoutness should avoid the high fuel fruits such as figs, dates, raisins, etc.—also jellies, jams and preserves.

FACTS ABOUT VEGETABLES

Variety in Vegetables. The statement that over 50 fairly common vegetables may be listed makes us realize our neglected opportunities in the matter of variety in selecting vegetables. Some of them may be confined to special localities, available only for a certain season, or expensive, but with the majority it is simply the inertia of not thinking to ask for them in the market or of not learning to cook them properly. With many little used vegetables, if the demand were greater, more of them would be available and at a lower price. This is true of some of the "lettuce substitutes" such as endive, escarole and romaine. Broccoli has achieved a considerable and well-deserved popularity since its introduction some years ago; it is not only popular in flavor, but pays a bonus in its very high content of vitamin C and calcium, as well as good values for iron and vitamin A. Artichokes have become less expensive, especially in regions where they are grown. As with fruits, modern transporation methods allow the city markets to offer their customers Texas tomatoes, Florida celery, Georgia asparagus and South Carolina lettuce while the snow is still flying in Northern cities. Cauliflower, spinach and cabbage are available almost all the year, and not at fancy prices.

Swiss chard, kale, and kohl-rabi are newer vegetables now quite extensively grown in private gardens. The last is a curious plant, related to the turnip, but bearing its root-like enlargement above the ground. The parsnip, vegetable marrow and salsify (vegetable oyster) are satisfactory only for occasional use, but the little used Chinese cabbage, palm cabbage, okra (when young and tender) and celeriac (a root with a flavor somewhat similar to celery) seem to be deserving of more extensive favor. The same statement should be made with greater emphasis with regard to turnip and

mustard greens, collards and kale—all of them green leafy vegetables that are surprisingly high in vitamin C, as well as fine sources of calcium and vitamin A. If properly cooked, they can be made very palatable and may be preferred to spinach, chard and beet tops, whose calcium content is unavailable but whose value for iron, vitamin A and riboflavin is similar to that of other leafy vegetables. Turnip tops are a staple article of the diet in some parts of the South, and are very useful in supplementing other foods so as to prevent deficiencies in the diet of the Negroes.

In European countries, onions, leeks and garlic have a wider use than in America. The two last named, together with both the red and green peppers, are useful flavoring agents with which to "add spice to the diet," while the onion is also excellent in food value and will not disagree with the digestion if its most highly flavored and irritating constituents are removed in boiling. The use in the raw state[1] of certain vegetables (cabbage, tomato, carrot, cauliflower or broccoli flowerets), when they are young and tender, is to be encouraged, since the loss of nutrients in cooking is thus avoided and when raw they have much higher vitamin C value. Green peppers are also especially high in vitamin C.

The tomato has been described as "a palatable solution of vitamins," and because of its vitamin C content, which is not reduced much, if any, by canning, it has been very widely used in recent years. It is also excellent for adding flavor to the more bland foods (macaroni, rice, etc.). The tomato, potato and corn are all plants which are native to America. The potato was introduced into Europe only after the expeditions of Sir Walter Raleigh. Because it is one of the cheapest energy foods, it now has an even more prominent place in the diet in several European countries (notably Ireland) than in America. Its lack of flavor is one of its strong points because it can be combined so well with other foods.

The STARCHY vegetables, which are real fuel foods, should be clearly differentiated from the LEAFY and SUCCULENT vegetables, which carry less energy for their bulk than practically any other class of foods. Celery, lettuce, tomato, eggplant and cucumber are about as near nothing in fuel value as anything we eat, but are useful for other reasons. Potatoes, and more especially peas, beans and corn, furnish a good deal of energy and protein.

In brief, then, starchy vegetables carry energy which must be allowed for if we do not over-eat; the legumes offer a cheap source of protein as a sub-

[1] Vegetables should be thoroughly washed before being eaten raw. If fecal matter is used as fertilizer (as in China), it is unsafe to use RAW any vegetables grown in or close to the soil, because of bacterial contamination.

stitute for meat. The leafy and succulent vegetables may be eaten in quantity and are the foods PAR EXCELLENCE for those who are constipated or overweight.

Cooking Vegetables. Vegetables are more abused in cooking than any other class of foods. It is no wonder that people refuse to eat the unpalatable messes which are usually served, but this is the fault of the cook and not of the vegetables, for good food is ruined in the cooking. This is graphically set forth in the following quotation from a novel, in which is described the final product of two cooks who had had the very same foods in their market-baskets. "Alma Petersen's string beans will look like a little pile of jade faggots, and will be as tender and stringless as new bamboo shoots. The beans prepared by the careless incompetence of Sloppy Ann will be a tangle of brown weeds, and they will taste like vegetable matter spread on paper and horsehair." The two words "careless incompetence" express the crux of the whole situation. No amount of explicit directions can supply the attentiveness to details and the interest, which are the real essentials for success in cooking vegetables.

The flavor and nutritive values of vegetables are best preserved by cooking in as SMALL AN AMOUNT OF WATER as possible (since most of the minerals and vitamins are soluble in water) and for as SHORT A TIME as possible. The exact time required to soften the fiber differs with the age and kind of vegetable varying from 2–3 minutes for young, tender ones (or others when cooked in pressure cooker) to half an hour or more for woody, fibrous ones. The pressure cooker is extremely popular for cooking vegetables, as its use shortens cooking time and conserves both flavor and nutritive elements. Long, slow cooking (stewing or baking in covered dish) is necessary to soften the fiber of dried legumes. Steaming, baking (with skins on), broiling or frying are ways of cooking vegetables which are suited to retention of minerals and vitamins. Boiling is especially good for vegetables that have a strong flavor. Green vegetables retain their color best when put into a small quantity of violently boiling, salted water, kept boiling vigorously, and cooked only a short time. Soda should NOT be added, as it facilitates destruction of vitamins during cooking. Overcooking renders many vegetables brownish and unpalatable. Cooking water should be saved for soups, except in the case of spinach, beets or beet tops, and strong flavored vegetables.

Nutritive Ranking of Vegetables. During World War II, attempts were made to rate vegetables in order of their composite nutritive return compared to cost, acreage, and labor required to produce them. It may be of interest to see the relative ranking given to some common vegetables in

the tables below. A high ranking means that the vegetable contributes much of several different nutrients, irrespective of cost; those lower in the table may furnish plenty of one nutrient but be low in others, or may give median or low returns in several. The first table takes into account fuel value, protein and minerals as well as their content of 5 vitamins; those given here are for EDIBLE PORTIONS only, although other tables were made which were on an "as purchased" basis and took amount of refuse into account.

(1)
Composite Nutritive Ranking of Vegetables in Terms of 9 Nutrients

1—Green peas, lima beans, broccoli
2—Sweet potatoes, artichokes
3—Brussels sprouts
4—Spinach, green asparagus, string beans
5—Cauliflower, sweet corn
6—White potatoes, cabbage
7—Turnips, beets
8—Carrots, celery, cantaloupes, green peppers
9—Tomatoes, lettuce, onions, winter squash, casaba and honey dew melons
10—Summer squash, radishes, cucumbers
11—Watermelons

(2)
Vitamin Ranking of Vegetables in Terms of 5 Vitamins

1—Spinach, broccoli, green peas
2—Green asparagus, sweet potatoes, lima beans
3—Cantaloupes
4—Brussels sprouts, cauliflower
5—White potatoes, string beans, tomatoes, winter squash, artichokes, green peppers, sweet corn
6—Cabbage, summer squash, honey dew and casaba melons
7, 8, 9—Turnips, beets, watermelons, carrots, cucumbers, lettuce, onions
10—Celery, radishes

Cautions for Vegetables

1. For adults and children who have a sensitive alimentary tract, which is irritated by fiber, either reduce the whole vegetables to a smooth purée by putting through a ricer (*e. g.*, spinach, cabbage, onions), or strain out skins, seeds, etc. and use only the pulp (*e. g.*, beans, peas, corn, tomatoes).

2. Persons who are inclined to be stout should avoid the starchy vegetables (potatoes, peas, beans, corn) but eat much of those with low fuel value (greens, lettuce, tomatoes, cucumbers, eggplant, etc.).

Dietary Rules for Fruits and Vegetables

1. Eat fruit at least twice a day.

2. Eat succulent vegetables at least twice a day—one of them a green, leafy, or yellow vegetable, if possible.

3. Eat potatoes (or other starchy vegetables) once a day.

4. Eat salad at least once a day.

QUESTIONS AND PROBLEMS

1. Name 4 vegetables that are high in fuel value, 4 that are high in protein, 4 dried fruits that are high in fuel value. Name 4 vegetables and 4

dried fruits that have a good iron content, 4 vegetables that are rich in calcium. Name 4 vegetables and 3 fruits that have high vitamin A value. Why is the vitamin A value of fruits and vegetables related to their color? Name 4 vegetables that are comparatively rich in vitamin B_1 (thiamine) and 4 that contribute the most vitamin B_2 (riboflavin). Name 4 raw vegetables and 5 fresh fruits that have a high content of vitamin C (ascorbic acid).

2. What are the main uses of vegetables and fruits in the diet? How do they supplement highly milled cereals, fats, sweets and meats in their nutritive properties? Why is it important to have a liberal supply of them? Is it necessary to spend much money for a wide variety of fruits and vegetables in order to get the benefits of a plentiful supply of them? Should those used in a low-cost diet be carefully chosen, and why?

3. Which vegetables and fruits are richest in fiber, which are poor in fiber, and which are especially laxative? Which are hardest and which easiest to digest? Which ones contain acids or give rise to acids that the body is unable to oxidize or burn up? Which ones are good "body alkalinizers," and why?

4. Give the classification of fruits and vegetables used by the U. S. Dept. of Agriculture. For each of the five classes, name 1 vegetable or fruit that you like and could include in the diet on the same day, so that each of these groups would be represented in 5 servings of vegetables and fruit. Repeat, using 5 other vegetables and or fruits, one from each class, which could be used on another day. Select the cheapest one from each group, a combination of 5 that could be used in a low-cost diet.

5. What are the chief nutritive characteristics of the following different parts of plants used as food: leaves, growing shoots or stalks, immature flower buds, fleshy roots, tubers, seeds, and fruits? Name 2 vegetables that are examples of each group.

6. Why is it important to use some raw fruits or vegetables? What proportion of the total vitamin C intake comes from fruits and vegetables? What influence does each of the following procedures have on the vitamin C content of foods: exposure to air, cooking a long time, cooking in much water, adding soda to cooking water? Why do these procedures affect the vitamin C content of foods? Give suggestions for conserving the vitamin C in fruits and vegetables during cooking, during storage, in the preparation of salads.

7. Kale, sweet potatoes and dried apricots have about the same vitamin A value. Which would be the least expensive and which the most expensive source of vitamin A?

The vitamin C (ascorbic acid) content of raw cabbage and oranges are

about the same, that of fresh tomatoes and pineapple about half as much, and canned tomatoes about one-third as much. Which would be cheapest and which most expensive for vitamin C?

Weight for weight, uncooked broccoli and milk contain approximately the same amount of calcium, and turnip greens twice as much. Which is the cheapest source of calcium? Equal weights of raisins and canned baked beans will provide the same amount of iron, the same weight of chopped meat about $\frac{2}{3}$ as much. Which food is the least and which the most expensive way to buy iron?

8. Consult the tables of composite nutritive rankings of some vegetables on p. 93. Those in Table 1 are rated on the basis of their content of energy and protein, as well as of minerals and vitamins; those in Table 2 on their value for five important vitamins. Select six high ranking ones on each list. Which ones occur high on both lists? Select four less expensive vegetables that occupy a high or median position in these rankings, that is, will give a good return in nutritive value for the money. Which inexpensive vegetables are good buys for energy and protein, which for vitamins?

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CHAPTER 7

FOOD ACCESSORIES

THERE ARE a good many substances which have little or no food value but which are taken along with food to add zest to the meal. As some of them have an important bearing on health, they deserve consideration in a separate chapter under the head of food accessories. A few of the substances taken up under this head do have nutritive value but hold an accessory position in the diet, since they are taken either between meals or as embellishments to a meal.

BEVERAGES

These include tea and coffee, cocoa and chocolate, soda fountain drinks, fruit drinks, egg and milk drinks.

Coffee and Tea. These two drinks should be considered together since they are essentially similar in their composition and action. They are highly prized adjuncts to the diet because of their pleasing flavor and aroma, because of the comforting influence that hot drinks have, and because these two special hot drinks possess a power of stimulation that tends still further to give temporary relief from fatigue and strain. The moderate use of these beverages may be relatively harmless or even beneficial under certain conditions, but their nature needs to be understood in order to guard against their misuse.

Tea is an infusion made from the dried leaves of the tea bush, and coffee from the roasted seed or bean of the coffee tree. Both are grown in the tropics or subtropics, most of the coffee now coming from Brazil and Central American countries, while the chief sources of tea are China, India, Ceylon and the East Indies. The active principle contained in both plants is an alkaloid called CAFFEINE, which has a stimulating effect on the heart, kidneys and central nervous system. Other drinks that contain stimulating alkaloids (*e. g.*, maté) are made from a number of different plants in various sections of the world, but cocoa and chocolate are the only ones beside tea and coffee which have a widespread use.

Besides caffeine, coffee contains caffeol, which is responsible for its flavor and aroma, and several substances collectively known as caffetannic

acid, which add flavor and "body" to the brew made from it. Neither of these is harmful and care is taken to retain the volatile caffeol in storing and brewing coffee. After grinding, coffee loses flavor and aroma fairly rapidly on exposure to air, the more so if finely ground; when packed in tightly sealed cans, there is little loss until the can is opened. In making the beverage, the volatile oils are extracted only by HOT water, yet if the liquid is allowed to boil or the container left open to the air much of them will escape in the steam.

The principal constituents of tea are caffeine, tannin and essential oils. The first supplies the stimulating quality; the second, the body of the brew in the cup; and the third its characteristic flavor and aroma. The presence of much tannin in a cup of tea is considered disadvantageous, since this substance has an astringent action and tends to retard digestion. As tannin is dissolved less readily than caffeine, the trick of making good tea depends largely on getting flavoring materials and some of the caffeine in solution while leaving the tannin behind in the dregs in so far as possible.

Black teas contain less tannin than green teas, because they have been subjected to an oxidative fermentation which destroys some of it. Oolong tea is a cross between green and black tea, as it is fermented only slightly. Different grades of tea also vary in tannin content. Teas are graded according to the part of the plant from which the leaves are taken, and the younger leaves contain less tannin. The grades are as follows—(1) flowery Pekoe or Pekoe tip (leaf buds at tip of shoots) (2) orange Pekoe (youngest leaves) (3) Pekoe (next leaves) (4) Souchong first.(5) Souchong second.

It will be evident from the above discussion that the amounts of caffeine, tannin and flavoring substances present in the water extractions of tea and coffee served as beverages are not fixed, but will vary considerably with the amount of dry material used, the kind of tea or the fineness of grinding the coffee, and especially with the method of making the beverage. The caffeine content of DRY coffee and tea do not differ materially, but because of the smaller amount of dry material used, a cup of tea usually contains less caffeine than a cup of coffee made according to the methods common in the United States, while if properly made the tannin content of tea may be kept low.

The **proper method of making tea** depends on using very hot water and allowing it to remain in contact with the tea leaves just long enough to extract the desired substances without dissolving much of the less soluble and objectionable tannin. Directions are as follows:

Pour FRESHLY BOILED water on tea leaves in a heated earthenware pot; stand pot in warm place three to five minutes to keep hot while steeping;

then, WITHOUT DELAY, either pour off the infusion into another (heated) pot or have tea leaves loosely confined in a cheese cloth bag and remove this bag from the pot in which the tea was brewed.

Three methods of brewing coffee are by boiling, by repeated spraying with water in a percolator, and by use of various types of coffee-makers that employ the drip or filtration principle. The trend is toward the last method, since in the first two the temperatures are too high and the time of contact between water and coffee is too long for best results, *i. e.*, the coffee will be strong, bitter, and contain a high amount of caffeine. The finer ground the coffee, the more favorable will be the conditions for quick extraction of flavor-bearing compounds and of caffeine. Hence fine ground or pulverized coffee is used for brewing coffee by the process of filtration.

The **best method of making coffee** so as to obtain maximum flavor and enough but not too much caffeine is by the process of FILTERING, carried out as follows:

Have pulverized coffee in the upper part of a glass or china container, which is pierced with small holes; pour the water on the coffee at boiling temperature, allowing it to filter through slowly and keeping as hot meantime as possible. If desired a muslin cloth or special filter paper may be placed over the holes in the upper part of the container. It is undesirable to keep coffee hot for long or to reheat it, as the temperatures which obtain in direct heating develop a bitter flavor. Coffee makers should be kept scrupulously clean.

The amount of caffeine in a cup of coffee may range from less than 1 grain to 3 or even 4 grains, but the average cup is said to contain about 1.5 grains. One grain of caffeine will produce noticeable physiological effects. Coffee and tea have been found to contain some of the water-soluble B-complex vitamins (especially riboflavin and niacin), although the nutritive value of the beverages made from them is usually considered to be negligible.

Decaffeinated coffees are on the market from which most of the caffeine has been removed, but which contain the normal amount of other constituents. Roasted grain preparations, offered as "coffee substitutes," of course contain no caffeine, but do contain certain coloring and flavoring substances that are developed in the roasting process, which are similar to substances found in the roasted coffee bean. Several ready-to-use coffee preparations are now available, which need only to be dissolved in hot water in the cup. The decoction has been made in the factory, where it was evaporated to yield the dry powder sold. Such preparations are naturally

highly concentrated products and should be used in small amounts, as otherwise the beverage prepared will be of high caffeine content. A few contain soluble dextrins or similar substances as a diluent, which is no disadvantage. Instant Sanka (decaffeinated) is also available now.

The **physiological action of caffeine** deserves fuller comment, though it is difficult to make general statements for two reasons—(1) because the sensitiveness of different individuals to caffeine varies greatly and (2) because the reactions of the body to the drug vary with the dose. People with comparatively stable nervous systems may show little or no effects from a dose that would cause an individual who is nervously unstable to be so much stimulated that hours later he would lie sleepless, with tense muscles and a feverishly active mind. As is true of all drugs, a small dose may cause one effect and a large dose another, while the amount which constitutes a large dose for a sensitive person may be a small dose for one who has become accustomed to the drug. These facts account for the many conflicting statements which we hear people make or see in books concerning the results of taking coffee or tea.[1] In order to clarify matters as much as possible for the reader, we will merely outline here what we consider the more usual effects of a moderate dose of caffeine on a person of average sensitiveness, who is accustomed to taking small amounts of some caffeine-containing beverage. The normal effect under such circumstances will be to QUICKEN RESPIRATION, STRENGTHEN the PULSE, slightly RAISE the BLOOD PRESSURE, STIMULATE secretory activity of the KIDNEYS, mildly EXCITE the functions of the BRAIN, and do away with any feeling of mild fatigue or depression which may have been present.

These effects are not unwelcome or disadvantageous to many persons in the morning, hence the prevalence of the coffee-for-breakfast habit. People seem physiologically to fall into two groups—those who start the day refreshed and brisk, and those who rise feeling jaded and have difficulty in starting the day's work. The latter type frequently show a slightly low blood pressure and sub-normal temperature in the morning, which accounts for their subjective symptoms. Such persons are often benefited by taking at breakfast a cup of well-made coffee which contains only a moderate amount of caffeine. However, the same influence, namely the quick-

[1] There is also a PSYCHIC factor to be taken into consideration in the effects which follow the drinking of tea or coffee. Shand says "One of the most curious things about coffee is the panic which the supposed effects of a single small cup will inspire among English people accustomed to take several cups of strong tea every day of their lives. Precisely the same sort of people in France regard tea as a most dangerous poison only to be taken in emergencies under direct medical advice."

ening of body processes and stimulation of the mind, may be disadvantageous in the evening, so that coffee should usually not be taken with the evening meal unless the stimulus is needed for some special evening event. As its action is not immediate, the maximum stimulation may come just at the time when sleep is or should be desired.

Probably the greatest danger in taking tea or coffee lies in their ability to relieve fatigue temporarily, so that proper rest is not obtained and fatigue thus becomes cumulative. It is a peculiar property of nervous fatigue that it may be thus covered up by excitement and not realized until it has become acute. All too many persons now-a-days are trying to keep up with the rapid pace of living by taking larger and larger amounts of coffee, rather than getting the extra rest periods which they so much need to build up their exhausted nervous reserve.

The coffee consumption of the United States has increased enormously in recent years until we now consume nearly one-half of all that produced in the world. Americans consumed 17 lbs. of coffee and only 0.7 lb. of tea per person in 1945. On the other hand, the average British citizen uses in a year less than 1 lb. of coffee and nearly 10 lbs. of tea.

Certain classes of individuals **should not take any coffee or tea.** The largest group of these persons to whom caffeine-containing beverages should be prohibited, is the CHILDREN. There is no question but that the use of these beverages is injurious to children. Savarin[2] made the observation that it caused them to be "puny" and Dr. Emerson,[3] nearly a century later, found that 72 per cent of the malnourished children examined by him used either tea, coffee, or both. Growth may be stunted by reason of malnutrition, and their nervous systems are too unstable to make it advisable for them to be allowed the use of so stimulating a drug. Likewise ADULTS who are either NERVOUSLY UNSTABLE (sensitive), or whose supply of reserve nervous force is depleted, should take little or no coffee (or use decaffeinated coffee). It is overstimulating for the former and makes them tense or irritable, while under the latter circumstances it serves to mask the tired feeling of those who are habitually violating one or more of the fundamental rules of health. Coffee may also be forbidden in certain diseased conditions such as heart disease and exophthalmic goiter. The excessive use of coffee or tea, even by normal adults, is exceedingly harmful as it leads to overstimulation to the point of irritation.

[2] See explanatory reference to this author on p. 296.

[3] W. R. P. Emerson, NUTRITION AND GROWTH IN CHILDREN, D. Appleton and Co., 1922.

Chocolate and Cocoa. Both of these are made from the seed borne by a certain tropical tree. These "beans" contain a stimulating substance called theobromine, which is closely akin to caffeine chemically and has a similar action on the body. This substance is present in about the same amounts as in tea and coffee, but theobromine does not stimulate to such a marked degree as does caffeine. Also when taken in a beverage, a smaller quantity of the dry substance may be used, since it is considerably diluted with milk. The solid, however, is incorporated in the milk in such a way that none of the contained compounds are left behind in dregs as is the case with tea and coffee.

Both chocolate and cocoa are highly nutritious beverages, whereas coffee and tea have very little nutritive value aside from that of the sugar and cream added to the beverage. Much of the fuel value of these substances is due to the fact that the cocoa bean consists of over 50 per cent fat. Chocolate is essentially the ground bean mixed with flavorings, sugar, and sometimes milk solids as in milk chocolate. In making cocoa, the beans are subjected to pressure so that about half of their fat content is removed (cocoa butter). The dry powder thus obtained is then blended with sugar and flavorings to make the commercial product sold as cocoa. These substances were listed in Table IV, p. 35, among foods rich in fat, and they contain varying amounts of sugar added in the "blending" process. Moreover, as we consume them, much of their nutritive value is due to milk and sugar added in making the beverage.

Because of their HIGH FAT content, these foods (especially chocolate) tend to RETARD DIGESTION too much to be taken in any quantity along with a heavy meal or with other rich food. Chocolate (either as beverage or confection) should be avoided by those whose digestive tract fails to handle fats well or is irritated by free fats. Cocoa is better for children and those with weak digestions (invalids), due to the fact that it contains less than half as much fat as chocolate. People who are inclined to be overweight should avoid both of these beverages on account of their HIGH FUEL VALUE.

In making cocoa or other milk drinks for CHILDREN, the cocoa should be used only IN SMALL AMOUNTS for flavoring the milk, and care should also be taken not to have such beverages heavily sweetened. It should be remembered that both cocoa and chocolate contain a STIMULATING substance, which makes them unsuitable for children in anything but very moderate amounts. Likewise chocolate as a confection should be used in small amounts only by children and by adults who are nervously sensitive.

Alcoholic Beverages. These deserve mention on two counts—their fuel value and their physiological effects. Alcohol can be oxidized in the body, each gram yielding about 7 calories; such beverages as contain sugar (wines, cordials, etc.) have further fuel value from this source. Beer and ales contain 3–6 per cent of "grain alcohol," wines 7–17 per cent, and distilled liquors 30–70 per cent. An average-sized glass of beer or ale furnishes 100–150 calories, a medium-sized wineglass of wine averages 100 calories, and a "jigger" (50 cc.) of gin, rum or whisky 115–150 calories. The caloric value of average portions of some commonly used alcoholic drinks will be found in a table in the Appendix. Alcoholic beverages contribute very little in nutrients other than their fuel value.

These drinks are consumed chiefly for the sense of well-being that they produce. Smaller quantities of alcohol cause increased flow of gastric juice and peristalsis, dilation of blood vessels, and a feeling of relaxation or exhilaration. Larger amounts irritate the stomach, interfere with digestion of other foods and depress the centers of nervous control in the brain, resulting in lack of coordination of muscular control, lessening of normal inhibitions, and slowness or confusion of mental processes. The variation between the effects of small and large doses of alcohol explains why some people (especially exhausted or elderly persons) are benefited by moderate use of alcoholic beverages (best taken with meals), while their excessive use leads to accidents and physical degradation. It should not be forgotten that such beverages are habit-forming and that persons vary widely in their sensitivity to alcohol.

Soda Fountain Drinks. The very extensive use of these drinks in the United States is to be condemned. It encourages the bad practice of taking food between meals, which may lead either to indigestion or overweight, and any considerable amount of iced drinks is bad for the digestion. On the other hand, the use of these dilute but bulky drinks, which are heavy with sirups, may cause children to come to the table without appetite and to neglect the more concentrated, nourishing foods, thus leading to malnutrition. Their food value depends chiefly on the amount of sugar or milk which they contain. If ice cream, chocolate or malted milk is added, the nutritive value is considerably increased. The occasional use of such food drinks between meals or as part of a meal will do no harm.

Special mention should be made of those soda fountain beverages which contain caffeine. Some of the caffeine extracted from decaffeinated coffee is put into soft drinks, which are estimated to account for more than one-tenth of all soft drinks sold in the country. Such drinks, advertised to "rest

you in five minutes," are bought daily by many who have no idea that they are imbibing a caffeine-containing beverage. They may easily contract the habit of taking too much of them, or of depending upon the stimulus thus derived to keep going when over-fatigued.

Fruit Juices and Fruit Flavored Drinks. Genuine fruit juices are refreshing and contain some EASILY ASSIMILATED NOURISHMENT in the form of simple fruit sugars or cane-sugar added. They are especially useful in the feeding of the sick, either for supplementary feedings between meals or where the diet has to be confined to small amounts of fluid nourishment at short intervals. Unless too much sugar has been added, they do not upset the stomach or sate the appetite. On the contrary, they may prove APPETIZING and promote digestion. They are one of the few foods which can be taken between meals without damage. They are excellent for children as a source of VITAMINS and MINERAL SALTS. Normal adults can take them in large quantities (if not sirupy or iced), and find them useful for their LAXATIVE effect and as ALKALINIZERS to counteract the effects of a diet in which acid-forming foods (meats, eggs and cereal foods) predominate (see p. 85). They deserve to be used in larger quantities.

Orange juice, grapefruit juice, grape juice, pineapple, raspberry and loganberry juice are favorites. All of them may be canned with but little diminution of their vitamin content. In diluted, sweetened form, such juices are used in fruit punch, orangeade, lemonade, etc. Cider is also a well-liked beverage expressed from apples. Apple juice and grape juice contain very little vitamin C, as compared with the other fruit juices listed above.

FRUIT-FLAVORED drinks should be differentiated from juices obtained from the first pressing of fresh fruits. Many soft drinks, either sold in bottled form or mixed at soda fountains, are flavored with very small amounts of true fruit juice, with an oil or extract made from the fruit, or with synthetic flavoring made to imitate that of the fruit. In many instances synthetic coloring matter and sugar sirup are added, or the beverage is carbonated. While such drinks may not be harmful, they contribute little or nothing in vitamin and mineral values in comparison with true fruit juices.

Egg and Milk Drinks. These are really FLUID-FOODS. Together with chocolate and cocoa they constitute the highly nutritious drinks, as contrasted with tea and coffee which contain practically no nutriment in themselves, while fruit juices occupy an intermediate position in this respect. Because of their fuel value they are VALUABLE in fluid diets FOR THE SICK and as supplementary nourishment for those who are UNDERWEIGHT.

Overweights should avoid them, of course. The whole egg may be used or only the white. Raw eggs are better digested and absorbed if well beaten, and may be combined with either milk or fruit juices. Milk drinks may be rendered more palatable by various flavorings, and more nutritious by the addition of egg, chocolate, cocoa, malted milk, or the pulp of non-acid fruits (banana, apricot or peach "nectar," etc.).

CONDIMENTS

Salt. The substance ordinarily spoken of as salt is a certain refined mineral salt (sodium chloride) which we add to our food either in cooking or on the table. The amount added is largely a matter of custom rather than of physiological need. Most of our foods contain considerable amounts of this substance in the natural state, and so our diet would probably provide almost (but not quite) enough of it for the body needs if we did not add any. Certain peoples, such as the Eskimos, add practically no salt to their food and the carnivorous animals eat no salt as such. However, civilized man has been accustomed to adding salt to his food for so many centuries that most foods taste flat and unpalatable to us without additional salt.

While we should find it hard to be reduced entirely to unsalted foods, there is no reason why we cannot train ourselves to prefer our food with only a moderate amount of salt added. This would be an advantage, since the excretion of a large amount of unneeded salt places an unnecessary burden on the kidneys. The early formation of a liking for little salted foods might safeguard health in later life. The addition of ANY salt to the food may be contraindicated in certain diseased conditions. When there has been excessive loss of salt from the body by profuse perspiration (as in heat prostration), small doses of salt are helpful in restoring the body to normal condition, and hence in relieving symptoms of prostration.

Salt is not a fuel food, as it is impossible to oxidize it, but it is a normal constituent of the body and as such is needed in small amounts to build tissue and to regulate body processes. It is also useful to enable us to eat some necessary foods which we would not relish if they were not salted, to give zest to certain foods (*e. g.*, ham, salted nuts, celery), and as an aid in the drying and preservation of foods (*e. g.*, salted codfish, dried beef). When used to excess, salt may encourage both overeating and overdrinking.

Pepper. While salt is a relatively harmless substance unless taken in excessive amounts, it is not possible to say as much for pepper. Few people realize how EXCEEDINGLY IRRITATING pepper is to the mucous

membranes that line the stomach and intestines, and especially to the kidneys. Since the body has no need for this substance, it would seem wise either to eliminate it entirely from the diet or to restrict its use to small amounts.

Paprika is the mildest of the peppers and it is really not a true pepper. It, together with cayenne and the pimientos, represent the pod-shaped, fiery-tasting fruits of the different species of capsicum. These so-called red peppers are rich in ascorbic acid or vitamin C, as are the immature green pepper pods used as a vegetable.

The true peppers are the ground berries of a climbing tropical plant. Black pepper is made from the immature berries and is only exceeded by cayenne in its fiery qualities; the ripe berries that contain larger amounts of starch are used to make grey and white peppers, which accordingly are milder and less pungent.

Spices. Most spices are not so irritating as pepper unless taken in large amounts. When taken in moderate amounts, they may be of some aid to digestion through stimulating the appetite and increasing the blood flow in the mucous membrane that lines the stomach. With excessive amounts of spices, however, their local action on the stomach membrane would produce undesirable irritation, and people who have sensitive or diseased stomachs should avoid them. The most irritating spices are mustard, horseradish, curry and ginger; these should be used very sparingly, if at all; most of the other spices (and ginger in the diluted form of ginger ale) are not sufficiently irritating to do any harm, if used with moderation.

Spices owe their special flavors to various volatile oils and other characteristic substances. Most of them come from tropical plants and the more common ones, together with their sources, are listed below.

Allspice—dried berries of tree in West Indies.
Cinnamon—inner bark of cinnamonum trees.
Cloves—dried flower buds of a tropical evergreen tree.
Ginger—boiled, dried root stock of an annual plant grown in the Orient.
Horseradish—ground root of a plant, either alone or mixed with vinegar.
Mustard—powder, ground seed of annual plant from which much of the fatty oil has been pressed out.
—paste, made of the powdered mustard and water.
Mace—dried covering which surrounds nutmeg kernel.
Nutmeg—seed of a tree which grows in the Malay archipelago.

Other spices, which are used only occasionally in this country but more extensively elsewhere, are anise, bay leaves, capers, caraway, cassia, marjoram, saffron, sage, savory and thyme.

Vinegar. The Pure Food and Drugs Act stipulates that vinegar must contain at least 4 per cent of acetic acid, and it is valued for the tart flavor which this acid imparts. The best liked vinegars are made from fruit juices by subjecting them first to alcoholic and then to acetic acid fermentation. The "mother" contains the organism responsible for the acetic acid fermentation. The choicest vinegars are those made from wine (Orleans and Tarragon), but cider vinegar is also of good quality and is more extensively used in the United States. Synthetic vinegars, such as those made from alcohol obtained by the fermentation of malted barley, glucose, etc., or from the destructive distillation of wood, are inferior but cheaper, and are widely used in commercial processes.

In such foods as pickles, vinegar serves to soften the fiber and to act as a preservative. It is most extensively used in salad dressings. Lemon juice has been much recommended to take the place of vinegar in salad dressings. A valid reason for preferring lemon or grapefruit juice is their high content of vitamin C, whereas vinegar contributes little or nothing in the way of vitamins and minerals. Excessive quantities of vinegar may be injurious.

QUESTIONS

1. To the presence of what substance in coffee and tea are their stimulating effects chiefly due? Describe the best methods of making these two beverages and tell why each of the steps is important for obtaining a good beverage. Why may improperly made tea and coffee be objectionable? Why may the moderate use of these beverages be beneficial and their excessive use be harmful?

2. Is caffeine a habit-forming drug in the sense that alcohol is? What are the effects of a small or moderate dose of alcohol? of larger amounts? Why may the moderate use of alcoholic beverages cause some persons to grow stout? Why will those who use them immoderately often be malnourished?

3. What is the composition of chocolate and cocoa? What is combined with them in preparing the beverages of the same names? What precautions need to be observed in giving them to children, and why? Can a chocolate bar have a stimulating effect and, if so, why? Why is the taking of iced soda fountain drinks between meals not a good habit?

4. For each of the drinks listed below, indicate which of the different classes of nutrients it supplies:

Beverage.	Food energy.	Protein.	Minerals.	Vitamins.
Cocoa				
Coffee				
Eggnog				
Lemonade				
Malted milk				
Brandy				
Ginger ale				

5. Does salt contribute any food energy? Is it necessary in the diet, and why? Do we need to add it to foods? What are the effects of excessive use of each of these condiments: salt, pepper, and mustard? Why is a person who is suffering from heat exhaustion given salt? Why is vinegar used in salad dressings, in making pickles? Does vinegar have any food value?

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PART

2

BODY NEEDS

CHAPTER 8

NEED OF THE BODY FOR ENERGY AND USE OF FOOD AS FUEL

WE DESIRE in this chapter to explain WHY THE BODY REQUIRES FUEL to keep it going, HOW THIS NEED IS SUPPLIED by the food, how to estimate THE FUEL VALUE OF VARIOUS FOODS, and how to tell in a general way WHETHER the diet is furnishing ENOUGH, TOO LITTLE, or TOO MUCH ENERGY.

Energy Needs. Energy is the power to do work and the body needs energy because it has certain indispensable work to perform. The energy needs of the average adult may be grouped under two main heads, namely for

(1) internal work.
(2) external work.

In addition, energy is SOMETIMES needed for

(a) growth or repair.
(b) heating the body.

The need for energy to build new tissue is almost entirely confined to the periods of childhood, pregnancy, or convalescence from wasting illness, and the amount needed for tissue repair in the adult ordinarily is so small as to form a negligible part of the day's food supply. Likewise it is not necessary to use up any food under ordinary circumstances merely for the purpose of keeping the body warm. A certain amount of heat is produced as a by-product whenever work is done and this is usually more than sufficient to maintain the temperature of the body at its normal of about 98.6° F. (37° C.) in spite of heat loss to the surroundings. Our modern conditions of clothing, heated houses, etc. keep down the loss of heat to such an extent that only when the air is very cold and the body is not sufficiently protected against heat loss is there any likelihood of having to draw on the food supply for the sake of maintaining body temperature. These factors will be discussed more fully when we take up the conditions where they are operative (HEAT-REGULATION, DIETS FOR CHILDREN, PREGNANT and LACTATING WOMEN, CONVALESCENTS, etc.), and in this chapter we shall

limit discussion to the two chief uses of energy for the adult—internal and external work performed by the body.

Internal Work. The body is often likened to a machine which requires fuel or energy to keep it going. A machine, however, needs energy ONLY when it is doing external work, while the body never has any period when it is completely at rest. It is a living organism most of whose tissues have to be continually active to maintain the life processes. IT MUST WORK TO LIVE.

About one third of the energy necessary for maintaining the vital processes is used by different **organs** in their various activities. *e. g.*, the beating of the heart, the work of the lungs, also of the chest and diaphragm, in breathing, the peristaltic movements of the stomach and intestines, and the work of glands such as the liver, kidneys and digestive glands in forming their secretions. But the greater part of the energy used to keep the body running, when a person is apparently completely in repose, is "due to oxidations in the resting tissues, principally in maintaining the tone of the skeletal muscles."[1] The **muscles** are never completely relaxed, and certain life processes go on in every cell even in sleep. Thus the energy required to keep the life processes going, even at slower tempo, during an eight hour period of sleep may be equal to the amount used by an inactive person for external work during the daytime, while in addition the internal work of the body has to be maintained throughout the day.

This internal work of the body—the irreducible minimum of energy necessary to keep it going when at rest and without food—is known as the **basal metabolism.**[2] It is comparatively CONSTANT in amount for the same individual, but varies slightly at different times and in different persons. The conditions which cause it to vary will be discussed in the following chapter (pp. 129–138).

External Work. The amount of visible or EXTERNAL work done is by far the largest single factor in determining the energy need of the body over and above the "BASAL" amount used when at rest. Whenever work is done, energy is used up. Even maintaining the body in the sitting or standing position involves the expenditure of considerable muscular effort which

[1] Sherman, H. C., CHEMISTRY OF FOOD AND NUTRITION, 7th ed., The Macmillan Company, p. 156, 1946.

[2] The word METABOLISM is a general term used to cover all the physical and chemical changes which go on in the tissues of the body. Under ENERGY metabolism we include those physical changes by which energy is transformed from one kind to another in the body, *e. g.*, chemical energy in food is set free as work and heat when food is oxidized as body fuel. As commonly used, however, the word metabolism is generally given the narrower meaning of the sum total of the CHEMICAL changes which take place in the body tissues.

requires energy. Small unconscious movements of the head, hands, and feet also use up a good deal of energy and when active work, such as walking, climbing, pushing, lifting, etc., is done a great deal more is required. The amount required is proportional to the work done.

In an inactive (sedentary) man or woman the distribution of the energy used during the day is usually about $\frac{2}{3}$ for the internal work of the body and $\frac{1}{3}$ for visible muscular movements. As soon as more exercise is taken, however, the energy required for external work mounts rapidly, while that needed for body processes remains constant. Thus the proportion of the energy used for visible work may come to be as much as $\frac{3}{4}$ of the whole, and the total amount of energy needed will be increased until it may be nearly tripled in cases where severe exertion is performed.

A man whose daily work is chiefly done standing or walking (*e. g.*, a carpenter or mason) will require approximately $1\frac{1}{4}$ times as much energy as one whose occupation is performed sitting (*e. g.*, a bookkeeper or shoemaker); a farm laborer will need $1\frac{1}{2}$ times and a ditch-digger or lumberman about $1\frac{3}{4}$ to $2\frac{1}{2}$ times as much energy as the sedentary worker requires. This means, of course, that those who perform tasks that require physical exertion must take more food in order to provide the added energy needed for external work, and the greater the amount of work done the greater the amount of food needed.

Similarity of Body to a Machine. This brings us to the question of how the body gets energy for work out of the carbohydrates, fats and proteins supplied in the food, which in turn brings us to the likeness of the body to a machine and how the machine gets energy out of its fuel. The body is similar to a combustion engine in the following respects:

(1) Energy for work is released by the **oxidation** or burning of fuel.
(2) It conforms to the law of the **conservation of energy.**
(3) **Heat** is a **by-product** of the transformations by which energy is released.

In the gasoline engine, gasoline vapor is mixed with air, ignited by a spark, and burned (or oxidized) with a resultant release of energy in the form of work and heat. The mechanical efficiency of the engine depends on how large a proportion of this energy can be converted into work. "The human machine, moreover, compares quite favorably in efficiency with man-made engines. It is a remarkably good steam locomotive which can convert 10 per cent of its fuel energy into mechanical pull upon the train of cars. Internal combustion engines do much better, reaching 20 per cent in the best automobile engines and 40 per cent in the Diesel steamship

engine."[3] The average mechanical efficiency of the body may be said to be about 20 per cent, which is about that of a good automobile engine. This means that to do a given amount of work about five times as much fuel must be used as would be represented by the work alone, since only about $\frac{1}{5}$ of the energy in the fuel is transformed into work energy and about $\frac{4}{5}$ of it appears as heat.

The energy set free as work and heat was stored up in the fuel in the form of chemical energy. Oxygen is always required for any combustion and is furnished from the air. Since no energy is ever created or destroyed, we may represent the transformations from one kind of energy to another, which occur when food or fuel are burned, by the following equation and will know that the total amount of energy must be exactly the same before and after the process of combustion:

Chemical energy in fuel or food + chemical energy in oxygen = chemical energy in gases formed + heat + mechanical energy used for work.

The **mechanical efficiency of the body** varies considerably. It is influenced by several factors not operative in the machine, such as the type of work performed, previous training or practice, fatigue, the amount of the load, and the speed and conditions under which the work is done. When the body is in good muscle tone and accustomed to the task (*e. g.*, in trained bicycle riders), efficiencies as high as 33 per cent have been obtained. Under unfavorable conditions such as unaccustomed task, too heavy a load, too high rate of speed, inconvenient posture for the task, or fatigue (even before it becomes conscious), the mechanical efficiency may fall as low as 10 per cent. Low mechanical efficiency means that work is accomplished at a greater cost, *i. e.*, more fuel and oxygen are needed to produce a given amount of work, while a large proportion of the energy appears as heat under these conditions.

During the recent war a great deal of research was devoted to determining whether the diet and physical condition of men could be a major influence in conditioning them for superior physical performance and warding off fatigue. The results were largely negative; no special type of diet seemed to promote vigor and combat fatigue better than a good mixed diet that met all body needs. However, in preflight meals for aviators flying at high altitudes, endurance was better after a meal rich in carbohydrates than one rich in protein. After prolonged periods of low calorie intake (semi-starvation), there was lessened efficiency in performing muscular

[3] Murlin, J. R., THE HUMAN BODY AS A MACHINE, in "Chemistry in Medicine," pub. by The Chemical Foundation, Inc., 1928.

work and various personality changes. Of course, a good general diet that supplies plenty of calories and training that accustoms the muscles to work does make for increased muscular efficiency. The physical condition of workers and working conditions in a factory can have a definite influence on its industrial output.

Even with the best mechanical efficiency, sufficient energy is necessarily diverted into heat to be more than enough under usual conditions to heat the body to the tropical temperature maintained in the tissues, so that the problem of heat regulation is generally one of getting rid of this excess heat. Everyone is familiar with the glow of extra heat produced by vigorous exercise, and heat in smaller amounts is a constant by-product of any action that involves work.

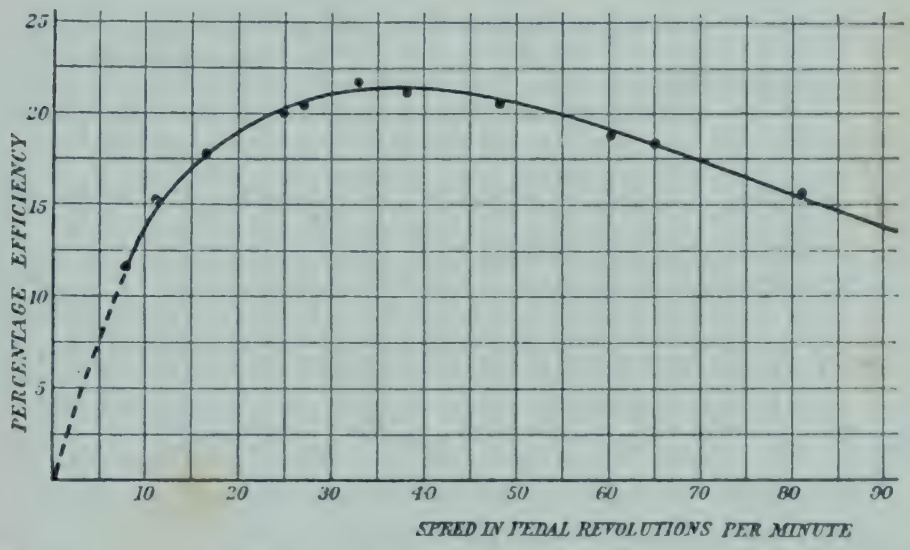


Fig. 12. Showing the efficiency of a cyclist at different speeds of pedaling. (Constructed from data obtained by Sylvia Dickenson. Journal of Physiology.)

Thus the body is strikingly like a combustion engine in its use of fuel to produce work and heat. Instead of the gasoline which serves as fuel for the automobile engine, it burns the **organic foodstuffs**, carbohydrate, fat and protein, for fuel and it requires **oxygen** with which to effect this combustion just as the engine does. Mineral salts and water can yield no energy to the body because they are already oxidized as much as is possible. The amount of energy which a given foodstuff is capable of yielding in the body depends upon its composition and the extent to which the body can oxidize it. Pure fats yield 2¼ times as much energy, weight for weight, as do proteins or carbohydrates. This is due to the fact that they contain so much UNOXIDIZED carbon and hydrogen as to form a very concentrated fuel, and

also that the body can burn them very completely. Proteins do not yield so much energy because they cannot be so completely burned in the body, and carbohydrates because they are already partly oxidized when eaten (*i. e.*, they contain a relatively high proportion of oxygen, enough to oxidize all the hydrogen in them).

The body can and does use these THREE foodstuffs interchangeably as fuel, although it probably uses carbohydrates most efficiently. The gasoline engine can use only one kind of fuel, but the human body can use three classes of substances for fuel. However, it seems probable that the energy actually used in the tissues comes chiefly from glucose, glycogen, or intermediate products of carbohydrate metabolism. Hence the ability of the body to use all three foodstuffs as fuel is mainly dependent upon the fact that it can transform fragments from the metabolism of fats and proteins into carbohydrate or closely related substances.

One more way in which the body resembles a machine deserves emphasis. This is the fact that one of the great laws of the universe, the law of the **conservation of energy,** holds true in living organisms as well as for inanimate things. This law states that no energy is ever created or destroyed so that the amount present must always be the same before and after any energy transformation. This means that the body can neither create nor destroy energy. All it gives out it gets from its food (or tissues) and all that is supplied in its food is sooner or later recovered in some form.

Stout persons who tell us that their bodies are running with an unbelievably small amount of food as fuel are fooling no one but themselves, for it is impossible that their bodies can create energy or get it out of water, salts or air.[4] It is frequently true, for reasons which will be given in the next chapter, that such people actually need less energy than those of normal weight but what they are using MUST come from solid food in some form and, if they are gaining weight, they are eating in excess of their energy needs no matter how little they are eating. On the other hand, if one performs a certain amount of work and does not eat food sufficient to furnish the energy for this work, he will necessarily grow thin, because the body will have to burn up some of its own tissues for fuel since it cannot create energy out of nothing. Thus persons who tell us that they can cut down their diet drastically for any considerable time without weight reduction are also asking us to believe the impossible. If they do not lose weight, it simply means that they have not reduced their diet enough so that it furnishes less fuel than the body needs.

[4] Except as the oxygen in the air (and only about $\frac{1}{5}$ of the air consists of oxygen) is used to oxidize body fuel.

TABLE VIII. COMPARISON OF BODY AND MACHINE IN USE OF FUEL

Body.	Machine.
1. Energy consumption never stops.	1. Need for energy stops as soon as machine ceases external work.
2. Can store surplus energy. 3. Can borrow from stored energy.	2 and 3. Machine has no ability to store fuel or to run on borrowed energy.
4. Energy released in muscular contractions is present all ready to be touched off, like that in a wound-up spring or charged electric battery.	4 and 5. Combustion engine has no ability to be charged ahead of time in readiness for action nor does recovery from action take place after work has ceased.
5. Considerable oxidation takes place after the work is over in order to prepare the muscle for next contraction—similar to rewinding the spring or recharging an electric battery.	
6. Muscle can: (a) adapt the effort to the amount of the load. (b) vary in mechanical efficiency under different circumstances.	6. Engine ordinarily does not possess either of these abilities.
7. Shows some loss of fuel through inability of body to completely digest and absorb food or to completely oxidize it in the tissues.	7. All of the fuel gets into the engine and should be completely oxidized, if ideal conditions prevail.

Points of Difference between the Body and a Machine. The analogy between the body and the combustion engine, while very striking in its main essentials, cannot be pushed too far. In a number of respects the living organism differs radically from the non-vital machine, and in practically all instances these differences represent advantages to the body in adjusting to its environment and varied needs. The more important differences have been suggested in the discussion of the body as a machine, given in the above paragraphs, but in order to be clearly understood they need to be pointed out separately. These dissimilarities between the man-made machine and the human body in their use of fuel and transformations of energy are summarized and contrasted in Table VIII, given above.

The fact that the **internal work of the body** goes on twenty-four hours

of the day and is absolutely essential to keeping up the life processes has already been emphasized in the discussion on the energy needs of the body (p. 112), so that it is unnecessary here to do more than point out that this condition is in direct contrast with the machine, which needs no energy at all to maintain it while idle. In fact the machine needs practically no material for repair. All it seems to need is lubricating oil to keep it in smooth running order and fuel while it is doing work. These are analogous to those substances in the food which serve to regulate body processes (water, mineral salts, and vitamins[5]) and the fuel foods used for external work in the body. In addition the body needs material for repairing wear and tear on its tissues, and for the continuous up-keep of the vital internal activities for which there is no counterpart in the machine.

Moreover, we all know that the life processes would not stop, nor would one even need to discontinue external work, if he stopped eating for a few days. It would certainly be more than inconvenient if the body had no ability to **store energy** and to draw in time of need on these energy stores in its tissues, but were obliged to come to a dead halt whenever the supply of fuel from without was withdrawn, just as the automobile engine does when the gasoline gives out. Fortunately, we possess a safety device which renders it almost impossible for the body to run out of fuel. Whenever there is a greater amount of energy in the food intake than is required to supply the current needs of the body, most of this excess energy is saved and stored up in the tissues.

The form in which extra fuel is usually stored in animals is in fatty tissue, and the body can work over an excess of carbohydrates and proteins in the diet and build them into fats for storage, as well as store directly any fats not needed at the time. The body can store only a very limited amount of carbohydrate as "animal starch" or glycogen, in the liver and muscles. This it uses for its "hand-to-mouth" supply of fuel, keeping the stores of fat as a reserve "fuel tank" to be drawn on only if there is a lack of ready fuel. While the body possesses almost no ability to store extra protein, the muscle tissues are very rich in protein and we have pointed out above (p. 115) that protein can serve as body fuel as well as fats and carbohydrates. As they form part of the most vital structures of the body, protein tissues are not drawn on for energy except in time of extreme need. With continued lack of food the body burns up its reserve fuel in the following order, first the limited amount of carbohydrate stored (glycogen), then the fatty

[5] The vitamins have also been likened to the ignition or spark that sets off combustion in the engine. This analogy is borne out by the recent discoveries that certain vitamins form a part of enzymes which are essential to oxidation in the tissues.

tissues, and finally the protein tissues. Thus under ordinary conditions of living we have a wide margin of safety as to fuel stored in the body, and run no risks of fuel shortage from SHORT periods of undereating or even of complete abstinence from food.

While the other ways in which the body differs from a machine are of considerable interest to the physiologist, they have not sufficient practical importance to warrant more than mention here. Food loss due to INCOMPLETE DIGESTION AND ABSORPTION is normally quite small in amount, averaging only a 2 per cent loss for carbohydrates, 5 per cent for fats and 8 per cent for proteins. Variations due to improper cooking or insufficient chewing of foods are smaller still, but under abnormal digestive conditions larger amounts of the food may escape digestion.

It is interesting to find that the muscle "almost thinks" by means of an adjustment, which can call more or fewer fibers into action according to the effort required of it. In this, as well as in the ability to VARY THE MECHANICAL EFFICIENCY under different conditions of work (see p. 114), we have points peculiar to the living organism and not shared by the machine.

In that physiological mechanism by which the muscle is prepared beforehand for the almost instantaneous mobilization of energy upon demand, and by which most of the real oxidation occurs in the process of recovery or RECHARGING OF THE MUSCLE for subsequent action, we have another point of superiority of the animal body over the machine. The energy for work is set free by oxidations in the muscles, as a result of which lactic acid is formed. An athlete may make a sudden and violent spurt, using all available oxygen in the tissues to oxidize part of the lactic acid produced by the exercise. The excess of lactic acid which accumulates in the muscles must be oxidized to get rid of the waste products, and it may require up to seventy minutes of breathing after the exercise is over to provide enough oxygen for this oxidation. The oxygen required for this purpose is called the "oxygen debt" incurred by the muscle tissue during exercise.

Energy Needs as Measured in Calories. Thus far in the discussion of body needs and food as fuel we have deliberately refrained from any use of the term CALORIES, and doubtless the reader has wondered why, since the word calorie has become almost a household phrase. It seemed best to keep the major discussion of energy requirements of the body and how they are met in general terms, so that the student might see the situation as a whole clearly before turning to the details of the quantitative measurement of fuel needs and fuel intake.

For the much talked-of calorie is merely a unit for the measurement

of energy. A person who is going to do a certain amount of work will need thus and so many calories to perform this work. Scientists have invented apparatus[6] and worked out means for determining accurately just how much energy the body uses for different jobs under varying conditions. If they have a chance to determine how much energy a given person requires per day for internal work, and know how many hours he works at various occupations, they can predict very closely how much energy he will use in a day. By similar kinds of instruments,[7] scientists have also determined how much energy each of the different foodstuffs gives when completely burned or oxidized outside the body. By making a small deduction to cover the average food loss due to incomplete digestion and absorption, and for the incomplete oxidation of protein in the tissues, they are able to tell just about how much energy any given food will yield to the body when ingested. The calorie is the yard-stick for measuring these quantities of energy, or the unit for expressing different amounts of energy in quantitative terms so that they can be compared. It is not food itself or heat as such, but a unit for the measurement of the fuel value of foods and for the energy produced by their combustion in the body—energy which appears, to be sure, in the form of work and heat. The CALORIE may be defined as **the amount of energy required to raise the temperature of one kilogram** (2.2 lbs.) **of water one degree centigrade** (or 4 lbs. of water one degree Fahrenheit).[8]

We may now translate into QUANTITATIVE terms, that is, express as CALORIES, the statements made in general terms above (pp. 112 and 115) in discussing body fuel needs and the energy value of the three foodstuffs. These facts are briefly summarized in Table IX, given on page 121.

The Food and Nutrition Board, of the National Research Council, in

[6] The instruments used to determine the amounts of energy produced by combustion in the body, or by the burning of foodstuffs outside the body, are called CALORIMETERS and they vary in type according to the use for which they are intended. All are built on the principle of a closed chamber, insulated to prevent loss of heat to the exterior, so that the heat increase may be measured, while the respiration calorimeter adds devices for measuring the amount of oxygen consumed and carbon dioxide produced in respiration. The newer instruments in use in hospitals for determining "basal metabolism" (see p. 112) merely measure oxygen consumed (when at complete rest), and from this the amount of energy set free by the use of this much oxygen in combustion is calculated (called INDIRECT calorimetry). Such an apparatus is shown in Fig. 68, p. 345.

[7] Called the BOMB CALORIMETER and OXY-CALORIMETER.

[8] This is the so-called "large calorie," which is the unit used in discussion of food and body needs. The "small calorie" is one one-thousandth of this amount of energy. The abbreviation for the large calorie is C. and for the small calorie is c.

TABLE IX. ENERGY NEEDS OF ADULTS AND FUEL VALUE OF FOODSTUFFS EXPRESSED IN CALORIES

Energy Needs in Calories per Day.			Fuel Value of Foodstuffs in Calories per Gram.
	Men.	Women.	
Basal, at absolute rest and without food, approx.	1600–1800	1250–1450	Fats . . . . . 9 Carbohydrates . . . . . 4 Proteins 4
Maintenance only, at rest in bed but with food, approx.	1750–2000	1400–1600	(The fuel value of a given weight of any food can thus be calculated from the number of grams of pure carbohydrate, fat and protein which it contains.)
At rest but sitting most of day	2000–2300	1600–1800	
Work chiefly done sitting	2200–2700	1800–2200	
Work chiefly done standing or walking	2700–3000	2200–2500	
Work developing muscular strength	3000–4000	2500–3000	
Work requiring great muscular exertion	4000–6000		

1948 revised their recommended daily allowances for energy as follows:

ENERGY NEEDS IN CALORIES PER DAY

	Men.	Women.
Sedentary	2400	2000
Moderately active	3000	2400
Very active	4500	3000

These are fairly liberal allowances, especially for the sedentary persons; a small man who does desk work and rides to and from work may require only 2000–2200 C., while an older woman whose chief exertions are bridge and knitting may need as little as 1600–1800 C. per day. Many of the earlier estimates of calorie requirements are too high for the "average" man and woman of today, since present-day living conditions call for less physical exercise than was customary a few decades ago.

Fuel Value of Foods. Calorie values are especially useful in thinking or talking of food as body fuel, because of the fact that **foods vary widely in their energy value.** Some are CONCENTRATED fuel so that it takes only a small bulk of them to yield a considerable amount of energy, or a large number of calories. Others contain much of nonenergy-producing substances such as water and cellulose (fiber), and only small amounts of

protein, fat and carbohydrate. Such foods are LOW IN FUEL VALUE, or yield a small number of calories to a comparatively large bulk.

In general, the foods with **high fuel value** will be seen to be those which are either RICH IN FAT or LOW IN WATER content. Foods of **low fuel value** are those which contain large amounts of WATER or of INDIGESTIBLE FIBER (cellulose). Foods moderately rich in carbohydrate and protein are usually intermediate in their energy value. Thus all the fatty foods listed in Table IV, p. 35, will be relatively high in calorie value, as will also foods low in moisture content such as cheese, nuts, dried legumes, dried fruits, etc. Fruits and vegetables, being rich in both water and cellulose, are low in fuel value, especially the green vegetables. Meats and cereal foods are intermediate in fuel value.

It is hard for most of us to carry EXACT calorie values for even the more common foods in our heads, and it is generally unnecessary to do so. However, it is often very useful to be able to estimate roughly the energy value of the diet taken, in order to check whether one is overeating or undereating as to his fuel needs. The easiest device for such an **approximate calculation of the calorie value of the food intake** is the 100 CALORIE PORTION. This means relative quantities of each type of food which it will be necessary to take to get 100 calories of body fuel. One may estimate, according to this 100 calorie unit or fractions of it, the approximate calorie values of the foods eaten, as follows:

	Calories (approximate)
1 tablespoonful or 1 large pat of butter, about	100
2 avg.-sized slices of bread, $\frac{1}{2}$ in. thick, about 75 calories each	150
1 egg ($1\frac{1}{3}$ egg = 100 calories) about	75
1 piece of double crust pie (100 cal. = a little more than $\frac{1}{4}$ of average serving) about	350
1 medium large orange (100 cal. = 1 very large orange) about	75

If one is able to visualize the relative BULK of different foods necessary to yield 100 calories, this helps to fix the foods of high and low energy value in the mind. It takes only 2 medium Brazil nuts, 4 dates, a 1-inch cube of cheese, 1 tablespoon of any clear fat, or 2 tablespoons of sugar to give 100 calories. On the other hand, 36 stalks of asparagus, 1 pound of cabbage, or 2 heads of lettuce are needed to yield the same amount of energy. Obviously the former group of foods are concentrated fuel foods and the latter are foods which carry very small amounts of energy. In the Appendix, pp. 568-573, is given a table of 100 calorie portions of some of the more common foods, which may be used for a rough estimate of the caloric intake.

More exact tables of the energy value of foods[9] are required for a fairly accurate check on the number of calories furnished by a day's diet. The 100 calorie portion is an arbitrary measure adopted chiefly for mathematical convenience. What we are really interested in are the caloric values of the size portions of foods which we ordinarily consume. The fuel values of **average servings** of the more common foods will be found in the table on pages 554 to 567.

An example of the manner in which the fuel value of a given food is calculated is given below.

Milk contains 4.9 gm. carbohydrate, 3.5 gm. protein and 3.9 gm. fat for every 100 gm.

Each gram of carbohydrate and of protein has a fuel value of 4 calories, and each gram of fat furnishes 9 calories.

100 grams of milk will have a fuel value of

$$\begin{aligned} 4.9 \times 4 &= 19.6 \\ 3.5 \times 4 &= 14.0 \\ 3.9 \times 9 &= 35.1 \\ \hline & 68.7 \text{ calories} \end{aligned}$$

A glassful of milk (8 oz.) weighs 240 grams, and hence has a caloric value of 68.7 $\times$ 2.4 or 165 calories.

How to Tell Whether Fuel Requirement Is Met or Exceeded by the Diet. While it is sometimes very interesting and helpful to get an idea of about how many calories one is taking daily, this is usually not necessary because there is a simpler way to tell whether the food intake just about equals the body requirement for fuel, or whether it provides less or more than the needed amount of energy. WHEN ENERGY INTAKE JUST ABOUT BALANCES OUTGO, THE BODY NEITHER GAINS NOR LOSES IN WEIGHT.

Variations in weight from day to day of as much as 1 to 2 lbs. are entirely normal and of no significance, because the body may vary enough in water content from time to time to account for weight fluctuations of this magnitude. If, however, the body weight is maintained constant over a considerable period of time, we can know that the food intake is adjusted so that it is practically equal to the energy requirements. But if the body weight is persistently, even though slowly, increasing, there is certainty that the fuel value of the food intake is greater than the energy needs of the body. When the healthy body is losing weight, we can be sure that the energy provided in the food is insufficient to meet the needs of the body.

[9] Tables of the energy values of 100 gram portions of foods are to be found in Misc. Pub. No. 572, U. S. Dept. of Agriculture (1945), as well as in numerous textbooks.

DISADVANTAGES OF OVEREATING OR UNDEREATING AS TO CALORIES

Consuming food which supplies calories in excess of body needs	leads to OVERWEIGHT, which leads to	lack of ambition inefficiency inconvenience embarrassment
	and may result in	diseases of the heart, circulatory system and kidneys diabetes lessened chances of long life.
Consuming food which supplies calories insufficient for body needs	leads to UNDERWEIGHT, which leads to	nervousness irritability loss of appetite indigestion listlessness lack of vitality lowered resistance to disease germs
	and may result in	anemia tuberculosis other infectious diseases sterility lessened chances of long life.

These conclusions are inevitable because of the fact that the body cannot create energy but must get it from the food or tissues (law of conservation of energy, see page 116). Whatever a fat or thin person may fancy to be the individual peculiarities of his body, that body goes on operating on the great principles or laws, which hold true in every living organism as well as in the inanimate world. It is impossible for a person to put on weight unless there is a surplus of energy supplied in the food; and, conversely, an addition to body weight necessarily means that, whatever the fuel value of the food was, it was in excess of body needs. Therefore, we have in **weight** an unerring index of whether the diet is equal to, in excess of, or inadequate for the energy requirements of the diet. "Watch your weight" and you will not need to calculate your calories with accuracy.[10]

[10] Approximate calculation of the calorie value of the average day's diet is especially valuable to let those who are underweight or overweight see more definitely where they stand as to food intake. Exact calculation of the calorie value of the dietary is NECESSARY for diabetics and in some other cases of illness and is of interest to those making a scientific study of food habits and the energy needs of the body.

MENUS SUPPLYING

2000–2100 calories.*	2900–3000 calories.*
Breakfast	**Breakfast**
Applesauce, $\frac{3}{8}$ c.	Orange juice, large glass
Toast, 2 slices, $\frac{1}{2}$ in. thick	Cereal, cooked, avg. serving
Marmalade, 1 tbsp.	Cream, thin, $\frac{1}{2}$ c.
Coffee with $\frac{1}{2}$ c. hot milk	1 egg
	3 strips crisp bacon
	Toast, 1 slice, $\frac{1}{2}$ in. thick
	Coffee with 1 tbsp. thick cream
Lunch	**Lunch**
Clear soup, 1 c.	Cream soup, 1 c.
2 saltines	2 saltines
Omelet, 2 eggs	Cold meat, 2 slices
Green salad, French dressing	Green salad, French dressing
Bread, 1 slice, $\frac{1}{2}$ in. thick	Bread, 1 slice, $\frac{1}{2}$ in. thick
Cottage cheese, 2 tbsp.	Baked apple
Cantaloupe, $\frac{1}{2}$ small	Tea
Dinner	**Dinner**
Roast lamb, avg. serving	Roast lamb, avg. serving
Potato, 1 medium	Potato, 1 medium
Peas, green, $\frac{1}{2}$ c.	Peas, green, $\frac{1}{2}$ c.
Carrots, med. serving	Carrots, med. serving
Bread, 1 slice, $\frac{1}{2}$ in. thick	Bread, 1 slice, $\frac{1}{2}$ in. thick
Cup custard	Pie, piece 3 in. at circumference
Cookies, 2	Milk, 1 glass
Day's allowance of:	Day's allowance of:
Sugar, $1\frac{1}{2}$ oz. or $3\frac{1}{2}$ tbsp.	Sugar, $1\frac{1}{2}$ oz. or $3\frac{1}{2}$ tbsp.
Butter, $1\frac{1}{2}$ oz. or $2\frac{1}{2}$ tbsp.	Butter, $2\frac{1}{4}$ oz. or $4\frac{1}{2}$ tbsp.

* In order to conform to the definite levels of calorie intake indicated here, the total amounts of food must be kept down to those specified in the menus. The day's sugar and butter allowance may be used in whatever way is desired.

If gaining weight to an undesirable extent, cut down on the total amount of food, especially on the high calorie foods; if losing weight unduly or if underweight, increase the total amount of food, taking as much as possible of the foods rich in fuel value. One may vary the diet within a wide range, according to one's tastes or to what foods are available at reasonable cost, yet know that the ENERGY needs[11] of the body are being met by the food

[11] It should not be overlooked that the body has needs other than its energy needs, which may not be satisfactorily met by a diet which provides enough calories. The requirements for protein, vitamins and minerals must also be met by the diet.

taken, provided the weight remains constant. This is the simple and inexorable logic, which is the "key to the calories" or the index of balance or lack of balance between fuel intake and fuel needs.

MENUS SUPPLYING A GIVEN AMOUNT OF ENERGY

In order that the reader may be able to visualize about how many calories certain types of menus will supply, we are appending two sample day's menus, in which the foods used closely parallel each other in kind, planned to yield respectively 2000–2100 and 2900 to 3000 calories. By referring to the recommended allowances for calories of the Food and Nutrition Board (given on p. 121), it will be seen that the first set of menus (p. 125) will furnish about the right amount of energy to meet the needs of a sedentary woman of average weight and the second set would suffice for the fuel needs of a moderately active man. Many persons eat LARGER AMOUNTS OF FOOD OR MORE OF THE FOODS HIGH IN FUEL VALUE THAN WOULD BE REQUIRED TO SUPPLY THEIR ENERGY NEEDS.

QUESTIONS AND PROBLEMS

1. Distinguish between energy in the objective sense (as used in science) and energy in the subjective or psychological sense (feeling energetic). In which sense is the term always used in nutrition? What is the unit used for expressing quantitatively the energy value of foods and energy needs of the body? Define the large calorie and give abbreviation for it. Why is the calorie, a heat unit, used for expressing energy values?

2. For what two main purposes does the body need energy? Under what special circumstances may additional energy be required for building new tissue or for heating the body? Which requires more energy per day—the muscular contractions of the heart or normal tension of the skeletal muscles, and why? Can muscular tension ever be completely eliminated? What circumstances increase it?

3. What is meant by basal metabolism? Is it identical with the internal work of the body and, if not, how does it differ? Does even the least active person do some external work and, if so, in what form? If a man lying quietly requires 77 calories per hour and his energy need sitting in a chair is 30 per cent higher, how much energy per hour will he need sitting at rest? If typewriting rapidly increases the energy need by 82 per cent over that lying down, how many calories will he use per hour sitting and typing? Is the amount of energy required proportional to the amount and severity of work done?

4. What is meant by the mechanical efficiency of muscular work? If a man did work that had a heat equivalent of 550 calories and used fuel equivalent to 2750 calories in the task, he would show a mechanical efficiency of 20 per cent (550 ÷ 2750 × 100), which is about normal. If another man had a mechanical efficiency of only 10 per cent, how many calories of fuel would he need to use to perform the same work as the first man? If a trained athlete had the high mechanical efficiency of 30 per cent, what would be the calorie value of the fuel he would need for the same job of work? What conditions make for poor mechanical efficiency, for good mechanical efficiency? In what form does the energy that is set free from body fuel but not transformed into work energy appear? Why does one feel hot after running, or other muscular work? Why does the heart beat faster and breathing become more rapid?

5. Give the calorie value PER GRAM of pure carbohydrate, protein, and fat used as body fuel. Calculate the fuel value of 100 grams of each of the foods whose composition is given below (by multiplying the grams of carbohydrate, protein, and fat each by the proper calorie value per gram, and adding these figures).

	Protein.	Fat.	Carbohydrate.
100 grams of white bread contains	8.5 gm.	2.0 gm.	52.3 gm.
" " " butter contains	0.6 "	81.0 "	0.4 "
" " " cabbage (raw) contains	1.4 "	0.2 "	5.3 "

What types of food are low in fuel value, high in fuel value?

6. Estimate the fuel value of the breakfast given below, using the table of 100-calorie portions of foods in the back of this book (pp. 568–573). Repeat, using the more accurate calorie values of these foods as given in the table of Nutritive Values of Foods in Average Servings or Common Measures (pp. 554–567). By how many calories does the approximate estimate differ from the second calculation?

Breakfast.	By 100-calorie Portions, Calories.	By Common Measures, Calories.
Orange juice, fresh, large glass (8 oz.)		
Cream of wheat, cooked, 1⅓ cups		
Thin cream, ¾ cup (6 oz.)		
Bread, toasted, 2 avg. slices		
Butter 2 avg. squares		
Coffee with 2 tbsp. thick cream		
Sugar, 5 tsp. (slightly rounded or 2 tbsp.)		
Total	_____	_____

Estimate the calorie value of the following breakfast (using either of the tables used above):

Orange juice, small glass (6 oz.)
Bread, 2 slices, toasted
Butter, 1 average square
Jam, 1 tbsp.
Coffee, with 1 tbsp. thick cream Total calories

7. Approximately how many calories per day does the average sedentary man require? the average sedentary woman? How many does a moderately active man need per day? a moderately active woman?

8. If a sedentary woman, whose energy requirement is 2000 calories daily, regularly eats food sufficient to provide 2500 calories daily, what will be the result? What will be the result if she eats only 1500 calories daily for several weeks or months? What is the law of the conservation of energy? Explain how it would work in these two cases. What is meant by the body being in energy balance? What happens to body weight in energy balance?

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CHAPTER 9

CONDITIONS WHICH DETERMINE THE ENERGY REQUIREMENT

It is obvious that some people need more fuel to meet their body requirements than do others. How can one tell whether his energy needs will be large or small, and what are the conditions which govern the amount of energy he will need? To study this question intelligently we must consider separately the energy needs of the body for INTERNAL and EXTERNAL work, since quite different factors operate to determine the amount of energy used for these two purposes.

BASAL METABOLISM

Basal metabolism is a term used to cover those chemical processes by which the body gets energy for INTERNAL WORK. It represents the irreducible minimum of energy required to keep up the life processes. It has been defined as the amount of energy required by the body when lying at rest, relaxed, and without food (twelve to eighteen hours after the last meal). There are two main factors which determine how much energy the body will need for its internal work, or its basal metabolism. These are

(1) The AMOUNT OF ACTIVE TISSUE in the body.
(2) The INTENSITY OF THE INTERNAL PROCESSES.

Amount of Active Tissue. Muscle and gland tissues are active tissues; bones and fat are inactive tissues. The chemical changes involved in the life processes of the cells go on rapidly in the active tissues and very slowly in the inert ones. Hence muscles and glands use a considerable amount of energy in their day's work, while bones and fatty tissue require little energy for their up-keep. Now what will determine the relative amounts of active and inactive tissues in the body of any given person? These factors are

(a) Total size.
(b) Type of body build.
(c) Sex.
(d) Condition of body.

Size. A large person will have a greater total amount of active tissue than a small one irrespective of other factors—*e. g.*, the body of a 150 lb. man

will contain a larger weight of muscle and gland tissue than that of a 50 lb. child, whatever the build of the two individuals.

Build. In the tall, slender type of individual (see Chap. 17, pp. 296–300) there is generally a larger proportion of the weight in the active tissues. The short, stocky build is inclined to carry a larger amount of weight in the inactive tissues, especially as fatty tissue, though in thin persons with a large skeletal framework the proportion of bone may be unusually high. In general, however, the tall, slender person requires more energy for his basal metabolism (per unit of weight) than the short, stout person.

Sex. It is rather doubtful whether sex, as such, has any direct influence on the energy requirement. Although there seems to be a slight rise in basal metabolism before menstruation, it is of minor importance as the changes range only from 2 to 5 per cent. However, sex does exert an indirect influence because of the fact that women usually have a larger proportion of fat than men. A well-developed layer of fat under the skin (subcutaneous fat) is the normal thing for women and is ordinarily lacking in men. The muscles of women are also apt to be smaller and more flabby because of their lesser muscular activity. Hence women usually require less energy than men, not only because of their smaller total size, but also because of the larger proportion of inactive tissue in their bodies and the lesser "tone" of their muscles.

Condition of Body. This factor is often not taken into account. A person who regularly takes a good deal of **exercise** will have less fat and more active muscle tissue than one of sedentary habits. His muscles will also show increased muscle tonus as a result of exercise. Athletes have a basal metabolism about 5 per cent higher than non-athletic men of similar size and shape. While it thus takes a little more energy to supply the basal needs (exclusive of external work) when there is a larger relative amount of active muscle tissue present, this should not be counted as a disadvantage if plenty of food is available, as the whole organism is in much better tone and health is improved when sufficient exercise is taken.

Likewise, the **dietary habits** bear a direct relation to body composition, which should not be overlooked. An individual who has been a heavy eater (*i. e.*, who has been accustomed to eating more food than he needed to supply his energy requirement) will have stored more fat than one who has eaten sparingly. His body will, therefore, contain a larger proportion of inactive tissue and his calorie requirement PER UNIT OF WEIGHT will be less than that of persons who are only moderately well nourished or decidedly lean. Undue leanness, on the other hand, predisposes to a relatively high basal metabolism per unit of weight.

Intensity of Internal Processes. The rate or intensity of the internal processes of the body depends on these factors:

(a) Age.
(b) Secretions of ductless glands.
(c) Sleep.
(d) Muscle tonus.
(e) After effects of { mental strain. / emotion. / exercise. / food. / fasting.

Age. The intensity of the internal processes is greater in youth and decreases slowly with advancing age. The term BASAL METABOLIC RATE is used to describe the relative intensity of the life processes in the body. The heart beat and respiration are more rapid, as are also the oxidation processes going on in the tissues, during infancy than in the adult.

The basal metabolic rate is highest between the ages of one and two years, increasing from birth up to this time with the gradual development of muscle tonus. After this there is a fairly rapid falling off in the rate of basal metabolism up to the fourth or fifth year, a gradual decline through later childhood, broken probably by a temporary rise in metabolic rate during the years of adolescence, and followed by a VERY SLOW progressive decrease throughout adult life.

From the best current figures, it would seem that the basal metabolism PER UNIT OF SURFACE AREA (see p. 135) in adult life (30–40 yrs.) is about 20–25 per cent lower than at its highest point in infancy (18 months). In the really aged (70–80 yrs.) it shows a further decrease of about 10 per cent from the level found at the "prime of life" (30–40 yrs). In the age group 18–20 years (college students) basal metabolism is about 4 per cent higher than in the 30–40 year group.

Based on weight, the basal metabolism of the young adult of average size comes close to one calorie per kilogram weight per hour, which makes 24 calories per kg. or about 12 calories per lb. per day. The basal metabolism of women is lower (usually by 6–8 per cent) than that of men (p. 130).

Secretions of Ductless Glands.[1] Quantitatively this is the most im-

[1] The ductless or endocrine glands manufacture substances that are absorbed directly into the blood stream and carried to all parts of the body. They include the thyroid glands (in the neck), pituitary and pineal glands (in the head), adrenal glands (just above the kidneys), the pancreas and the sex glands. These glands will be more fully discussed in Chap. 19.

portant factor in influencing basal metabolism and the secretion of the THYROID glands has a far greater influence on the rate of the internal processes than that of any other glands. Thyroxin, the iodine-containing substance secreted by the thyroid, has a very potent influence in speeding up all the oxidative processes of the body. When the thyroid glands are overactive they form too much of this substance, and basal metabolism becomes much more rapid than normal; in abnormal conditions where the thyroid glands are underactive, the amount of thyroxin formed by them is too small to keep the basal metabolic rate up to what it should be. This substance is so potent that 1 milligram[2] of it is sufficient to increase the energy metabolism 2–3 per cent, and a single administration increases the basal metabolic rate for 5–6 weeks, in a person who has little or no thyroid tissue. It is remarkable that in a person in normal health the amount of this potent substance secreted by the thyroid glands is regulated to such a nicety that the basal metabolism (energy output for internal processes) is kept at a constant and normal rate.

The internal secretion produced by the adrenals, two small glands situated just above the kidneys, also exerts an influence on basal metabolism, though not so markedly as does the thyroid secretion. Stimulation of the adrenal glands (such as happens in fright, excitement and other emotions) causes a temporary rise in the metabolic rate, while it has been shown that cats have a fall of about 25 per cent in basal metabolism after an operation to remove these glands. The pituitary and sex glands also have an indirect influence on metabolism.

Sleep. The chief effect of this factor in decreasing the internal work of the body comes through the relaxation of muscular tension which takes place during sleep. It has been established that there is also some specific slowing down of the internal processes during sleep. In adults, the average basal metabolism when asleep is about 10 per cent lower than when lying quietly but awake.

Muscle Tonus. Everyone knows the difference between a condition where the muscles are tense and one where they are well relaxed. What most people do not appreciate is that the muscles are NEVER completely relaxed, as it is necessary that they maintain a certain amount of tension (spoken of as muscular tone or tonus) even in sleep, and that keeping up the normal muscle tonus involves considerable internal work. The amount of energy required for muscular tension will vary considerably with the de-

[2] A milligram is one-thousandth part of a gram. The gram is the weight unit in the metric system and is about $\frac{1}{28}$ of an ounce, when translated into the English system of weights.

gree of tenseness or relaxation of the individual, but always bulks large in comparison with the energy needed for heart beat, breathing and other internal activities, because the total amount of muscle tissue is so great.

Any person who is under strain, nervous and apprehensive will show a high degree of muscular tenseness. Even in the absence of such conditions, the greatest degree of relaxation will be found on first waking and muscular tension will increase as the day advances. For these reasons, it is best to make tests for determining basal metabolism early in the morning, to have the subject lie quiet for half an hour or more beforehand, and to further



Fig. 13. A photomicrograph of a single muscle fiber contracting. (By permission from Schafer: Essentials of Histology.)

secure muscular relaxation by reassuring him that the test will not cause discomfort. Even with these precautions, a second test will often give lower figures than the first (and therefore more truly represent "basal" metabolism), because muscular tension is less after the subject is accustomed to the apparatus and procedure.

AFTER-EFFECTS OF VARIOUS CONDITIONS

Emotions and Mental States. These act on basal metabolism in several ways, probably the most important of which are through their effect on the ductless glands and on muscular tension. It has been mentioned above

that stimulation of the adrenal glands, such as takes place under emotional stress, results in an increased rate of body processes. The effects of adrenal stimulation are exhibited to a high degree in cats when excited by the sight of a dog. Many emotional states that involve fear or joy show an influence on the intensity of internal processes, and mental states also affect body processes, though usually to a lesser extent. The most marked effect of mental strain seems to be in increasing muscular tonus, and the tenseness of the muscles during suspense, anxiety, excitement or even during mental work is a familiar phenomenon.

Exercise. Of course when we are talking of BASAL metabolism, or the energy required for internal processes only, exercise is ruled out since basal metabolism always means metabolism at rest. However, the AFTER EFFECTS of severe muscular work persist for a long while after the work has ceased (see explanation of recovery from work or "oxygen debt," p. 119) and it has been found that the basal metabolism during the night that follows a day in which much exercise was taken, is higher than after an inactive day. The oxidative recovery processes keep going on in the body for hours after SEVERE muscular effort and for shorter periods after less strenuous work.

Food. The immediate influence of food is likewise ruled out in basal metabolism, which is always taken twelve to eighteen hours following a meal, but the after effects of food sometimes linger on into the resting period as is the case with exercise. The products of the digestion of protein food seem to stimulate or whip up metabolism, so that following a day when a great deal of protein had been eaten the basal metabolism would be higher than after a day when the diet had been mainly carbohydrates and fats (see paragraph on influence of food, p. 139).

Fasting. In PROLONGED fasting or semi-starvation the body seems able to adjust itself to a slightly lower level of metabolism in order to conserve its energy when a very limited supply of fuel is available. The internal processes will thus be somewhat slowed down and the basal energy requirement will be lower after a long fast or in an adult whose food supply has been insufficient for his needs for some time. This adjustment of the body to run with greater economy of energy does not occur in a short period of food deprivation.

During World War I, a group of 12 young men students volunteered for a prolonged period of underfeeding as to calories. Benedict[3] found that, when they had sustained an average loss of weight of 12 per cent, there was an average lowering of basal metabolism per unit of body weight by

[3] Benedict, Miles, Roth and Smith, Carnegie Institute of Washington, Pub. No. 280, 1919.

18-20 per cent. Recent experiments in undernutrition[4] likewise showed an average 18 per cent reduction in the metabolic rate (together with a lowered expenditure of energy for exercise) on a daily fuel intake of 1500 calories per person. But in undernourished children there is sometimes a higher than normal basal metabolism per unit of weight. Persons who are underfed as to calories suffer a loss of morale, physical strength, and endurance.

RATE OF HEAT LOSS AND TEMPERATURE REGULATION OF BODY

Naturally if much heat is dissipated from the surface of the body, it will take more fuel to maintain its normal temperature, which is considerably above that of the surrounding air under ordinary circumstances. If heat loss from the surface is low, there will be no need to oxidize food material for this purpose, since the heat formed as a by-product of even the internal work of the body (including muscular tension) will suffice. When external work is done, the amount of heat available (as a by-product of work) is still further increased. The main factors which affect the rate at which heat is lost from the body surface are

(a) The relative amount of surface.
(b) The presence or absence of a layer of fat under the skin.
(c) The relative amount of insulation { clothing. / shelter.
(d) The environment { temperature of the air. / humidity of the air. / movement of the air.

Relative Amount of Surface. By this we mean the extent of surface area in proportion to the amount of body tissue. A child has a larger amount of body surface in relation to its total size than an adult, the tiny infant having the largest relative amount of surface for its size. SHAPE of the body also influences the relative amount of surface. A tall, thin person possesses about $1\frac{1}{2}$ times as much surface area as a short, fat person of the same body weight. Since heat loss is through the surface, the body with a large amount of surface will have to generate more heat to maintain its normal temperature than one with a relatively smaller surface exposure.

While the TOTAL energy production thus varies with the size, shape and composition of the body, the heat production per UNIT of SURFACE area is a remarkably constant quantity. In adults, the influence of these factors disappears almost entirely when results of metabolism tests are reported in

[4] Mitchell, H. H., "Adaptation to Undernutrition," J.A.M.A., v. 20, p. 511, 1944.

terms of calories per unit of surface area (sq. meter) rather than per unit of weight (pound or kilogram).

Surface area is a less important factor in adults than with infants and children, where there is a larger proportion of surface to volume. If too much of the body surface is exposed in children, they may be obliged to use fuel for body warmth, which could otherwise be used to advantage for growth. This is the main objection to dressing children in such a way as to leave the arms and legs bare in cold weather.

Subcutaneous Fat. We have spoken of the layer of fatty tissue directly under the skin, which is normal for most women. This layer of subcutaneous fat varies considerably in extent and thickness in different individuals according to sex, general build and dietary habits. Fat is a very poor conductor of heat, or a good insulator, so that those persons who have a well-developed layer of fat under the skin lose heat to the exterior much less readily than do those who have little subcutaneous fat. "Thin people have been proved to radiate fifty per cent more heat per pound than fat people; in other words, fat people are regular fireless cookers!"[5] This may be an advantage in winter but acts in the opposite direction in hot weather when, because the heat is held within by this layer of "packing," fat people are more subject to heat prostration, especially if they generate any extra heat within their bodies by exercise.

Insulation. CLOTHING AND SHELTER. There are other insulators besides fat. In summer, we leave some of the body freely exposed and wear loose clothing of porous weave and light color which allows heat to escape readily; but in cold weather we resort to covering the body with several layers of clothing usually of thicker, less porous material and dark in color. Winter clothing usually helps considerably in conserving body heat. It might be worth while to point out that poor people, who are unable to get sufficiently warm clothing with which to protect themselves in winter, often become thin because their supply of food is apt to be limited and it is necessary for them to burn their own tissues to keep their bodies warm. The recent fad of young girls going scantily clad in winter, while eating as little as possible, may also bring about the same result.

The part which shelter plays is equally well known. Even primitive housing conditions protect somewhat from extremes of temperature and from exposure to the elements, but civilized man has now equipped his houses with heating devices so that summer heat can be maintained in them throughout the winter season. In fact with modern conditions of heating houses in the United States, the body is very seldom called upon to burn

[5] Peters, L. H., DIET AND HEALTH, Reilly and Lee Co., rev. ed., p. 16, 1939.

any of its fuel for the purpose of maintaining its normal temperature. Our latest developments in "air conditioning," which now permit homes and public buildings to be kept at constant temperatures both winter and summer, are a further factor in ruling out the influence of the seasons on body temperature.

Environment. Cold-blooded animals like fish and frogs have no ability to regulate their body temperature, which accordingly rises and falls as the temperature of their environment changes. Man and the other warm-blooded animals possess a heat regulating apparatus, which keeps their body temperature almost constant at a point which is usually considerably higher than that of their surroundings. Small variations of body temperature are normal but practically never exceed 1° F. in health.

There are only two conditions under which changes in the temperature of the environment will have any effect on basal metabolism. First, if the body surface is insufficiently protected from heat loss and the temperature of the air is sufficiently low, extra fuel must be burned to keep body temperature up to normal. In such a case, there is likely to be shivering (involuntary muscular activity) and increased oxidative processes in the tissues to generate the extra heat needed, so that the basal metabolism will be increased.

Conversely, in **fevers** when heat loss from the surface is prevented, the temperature of the body itself will rise. Since the rate or intensity of the internal processes is speeded up by a rise in temperature, the basal metabolism will be increased in this case. It has been calculated[6] that the increase in energy expenditure is about 7 per cent for every degree Fahrenheit rise in body temperature, or a fever of 4 degrees (102.6° F.) would call for 490 extra calories added to the basal metabolism of an average-sized man.

The practical application of these facts lies in the knowledge that a somewhat larger supply of fuel foods is needed in winter, especially if the clothing is insufficient or if there is considerable exposure, while in so far as is possible extra food should be given to fever patients to meet their increased demands for energy.

Normal Heat Regulation. Temperature regulation is ordinarily accomplished in the body without effect upon the basal metabolism or total energy needs. Excessive heat loss is prevented (either by clothing, shelter, fat layer, or high temperature of air) and the heat produced as a by-product of body processes and muscular work is more than sufficient under these circumstances. HEAT REGULATION THUS IS USUALLY A PROBLEM OF GET-

[6] DuBois, E. F., BASAL METABOLISM IN HEALTH AND DISEASE, 3rd ed., Lea and Febiger, 1936.

TING RID OF THE SURPLUS HEAT PRODUCED. About 80 per cent of this excess heat is got rid of through loss at the body surface, or through the skin. Some is lost through the lungs by evaporation of moisture in the expired air and a small amount in the excreta.

Heat is lost from the skin by (1) **radiation** or **conduction** and (2) by **evaporation** of moisture. The relative ease with which heat can be got rid of from the skin by one or the other of these two paths depends on the surrounding conditions. Low temperature of the air favors heat loss by

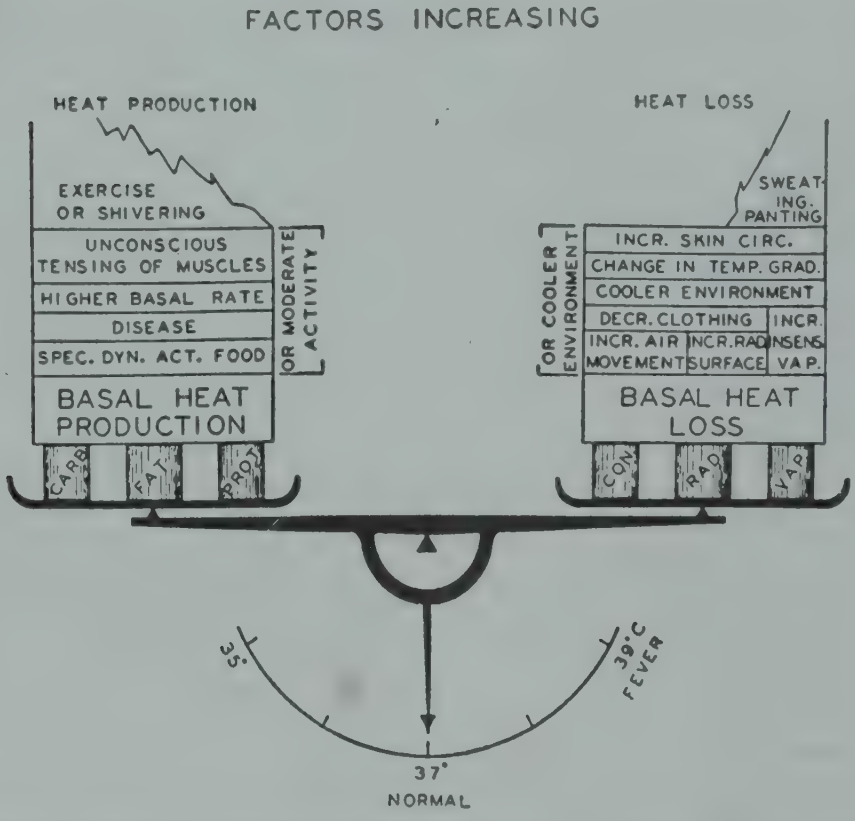


Fig. 14. Balance between the factors increasing heat production and heat loss, which keeps body temperature normal. (DuBois and Chambers: Handbook of Nutrition, American Medical Association.)

conduction, while high temperatures cut down heat loss by this means and favor loss by evaporation. Low humidity aids evaporation and high humidity reduces the opportunity for loss of heat through this channel. Wind or circulating currents of air favor heat loss by both conduction and evaporation. A further aid in temperature regulation is the variable amount of blood sent to the surface under different conditions of heat and cold; the skin becomes flushed on a hot day and blanched or bluish on exposure to cold. These facts are so familiar from experience as to need no further em-

phasis. The important fact is that only under exceptional conditions does the adult[7] need any extra fuel for maintaining normal body temperature.

ENERGY NEEDS ABOVE BASAL REQUIREMENT

The body NEEDS ENERGY IN EXCESS OF that required for ITS INTERNAL PROCESSES (basal metabolism) for the following purposes:

1. To cover the effect of food.
2. To do necessary muscular work.
3. To provide any excess needed in { growth. / pregnancy. / lactation. }

Effects of Food. No one could live long on the basal level of energy requirement, for he could not live without food, the taking of which in itself raises the energy output. This effect of food comes not because of energy required to digest the food but from the fact that the products of its digestion, after they are absorbed, stimulate the "fires of metabolism" in the tissues to burn more brightly. In the case of the digestion products of the fats, energy metabolism seems to be increased mainly because a larger amount of oxidizable material is brought to the tissues by the blood. Carbohydrates seem to act in a different way, *i. e.*, due to the heat of chemical reactions required for their metabolism in the tissues. Proteins may act in a similar manner, although it is generally thought that some of the products of digestion or metabolism of protein act not merely as fuel but as direct stimulants to the metabolic processes. This is called the SPECIFIC DYNAMIC ACTION of protein.

The rise in metabolism after eating carbohydrate food will be only 6 per cent of the total fuel value of the food eaten (106 calories for every 100 calories carbohydrate consumed), and the increase caused by fat is not very different in magnitude. The rise in metabolism after taking 100 calories of protein is much greater, however, amounting to 30 to 40 per cent or 130–140 calories energy output. On an ordinary mixed diet, the usual allowance to cover the stimulating effects of the food itself is about 10 per cent of the total intake. DuBois thinks that 6 per cent is sufficient allowance for the influence of food on a mixed diet. Thus, in order to have his energy intake equal to output so that weight is maintained, a man whose energy needs for internal work plus muscular work amount to 2000 cal-

[7] Infants and children may require some energy for this purpose unless the surface of their bodies is adequately protected from heat loss (see p. 136). Elderly or sick persons, whose vitality is low, may also suffer undue heat loss unless warmly dressed or in a warm room.

ories, would require at least 120 and perhaps as much as 200 extra calories to cover the effects of the food. If the diet contains a great deal of meat the increase in metabolism may amount to 18 per cent, or even more.

Aside from making this necessary extra allowance to cover the increase in metabolism caused by the food, the chief significance of these facts lies in the observation that more protein may be included in the diet in winter. The extra energy set free in the body due to the stimulating influence of the protein can be utilized to keep the body warm, though it cannot be used for doing work. Conversely, the eating of much protein in hot weather is inadvisable, since the extra heat generated adds to the discomfort at a time when it is difficult to get rid of surplus heat.

Muscular Work. This is BY FAR THE MOST IMPORTANT of those factors which raise the energy requirement of adults above that necessary for mere maintenance. Thus, if the energy metabolism of a man sitting still is estimated at 100 calories per hour, the metabolism of the same man WHEN WORKING may range from 300 to 600 calories per hour, according to the amount and kind of work done and the conditions under which it is done (mechanical efficiency, see p. 114). To get an idea of how much larger the increase in energy need that results from external work is than that resulting from any other factor, compare this 200–500 per cent increase in metabolism due to active work with the 6–10 per cent increase due to the influence of food.

Of course such an active energy ouptut cannot be kept up for very long at a time, so that the total increase in energy requirement for the day (working eight hours) will not be more than 50–100 per cent over the maintenance requirement even for active workers, and the higher figures given are obtained only in such a strenuous occupation as that of lumbermen. Translating these general statements into calorie requirements, we may estimate the fuel requirements for persons in occupations that involve different degrees of physical activity as shown in Table X.

Under modern living conditions, the energy requirement of many men and women will be largely determined by the amount and character of the exercise taken. When a man's work calls for little physical activity, the total energy required for muscular work may be only about 500 calories daily, or even less. The minimum daily energy requirement for a sedentary man of average weight (154 lbs.) might thus be

	Calories.
For basal metabolism	1700
For ordinary muscular activity	500
	2200
To cover effect of food (6 per cent)	132
Total	2332

TABLE X. FUEL REQUIREMENTS OF VARIOUS OCCUPATIONS

Men.*		Women.*	
	Calories per day.		Calories per day.
Unemployed	1900–2200	Unemployed	1600–1800
Sedentary work:		Sedentary work:	
Clerk, office worker, teacher, student	2200–2500	Stenographer, clerk, teacher, seamstress	1800–2200
Light work:		Light work:	
Tailor, shoe maker, book binder, weaver	2300–2600	Housekeeper (light work) machine operator (factory)	2000–2300
Moderately active work:		Moderately active work:	
Carpenter, painter, metal worker	2700–3100	Farm or heavier housework	2300–2700
Active work:		Active work:	
Farmer, mason, soldier in training	3100–4000	Heavy laundry work or scrubbing	2700–3000
Very active work:			
Coal miner, excavator, blacksmith, lumberman	4000–6000		

* The range of energy requirement for the same occupation is due chiefly to differences in the size and degree of activity of different individuals. These figures are condensed from those given by Orr and Leitch and presuppose 8 hours of work at the various occupations listed.

Two hours of light exercise (walking to and from work) would increase his calorie requirement to over 2600 C., while two hours of active exercise (strenuous sports) would raise it to over 2900 C.

If we wish to estimate the energy requirement more precisely, we may do so by obtaining a detailed account of the hours spent at different types of activity during a sample day and computing the energy used in each activity by means of figures such as listed in Table XI (which include basal metabolism and effect of food).

For approximate estimation of calorie requirements, it is sufficient to multiply the weight in kilograms or pounds (1 kg. = 2.2 lbs.) by the appropriate figure in one of the last two columns of the table on page 142 (estimate on a 24 hr. basis). For example:

A woman weighing 54.5 kg. (120 lbs.) at occupation requiring moderate exercise—
54.5 × 35—40 = 1907—2180 Calories.
A man weighing 150 lbs. at occupation requiring active exercise—
150 × 18—20 = 2700—3000 Calories.

TABLE XI. ENERGY REQUIREMENT FOR DIFFERENT DEGREES OF ACTIVITY PER UNIT OF BODY WEIGHT

Activity.	Per Hour		Per Day	
	per lb.	per kg.	per lb.	per kg.
Sleeping	0.43	0.93	12	24
Awake, lying still (with food)	0.5	1.10	14	30
Sitting at rest	0.65	1.43		
Sitting at work	0.7–1.0	1.6–2.0	15	30–35
Standing relaxed	0.69	1.50		
Standing at attention (tense)	0.74	1.63		
Walking slowly (approx.)	1.30	2.86		
Walking fast (approx.)	1.95	4.28		
Light exercise (housekeeping)	1.10	2.43		
Moderate exercise (carpentry)	1.56	3.43	16–18	35–40
Active exercise (sawing wood)	1.88	4.14	18–20	40–45
Severe exercise (running at 5 mi. per hr.)	3.70	8.14	20–27	45–60

Mental Work. MENTAL WORK DOES NOT AFFECT THE ENERGY REQUIREMENT APPRECIABLY except as it may be accompanied by muscular tenseness. While the metabolism of nervous tissue can be shown to be increased by activity, the amount of energy required is sufficiently small and the proportion of nervous tissue in comparison to the total body weight is so low, that the influence of its activity is like "a drop in the bucket." Benedict and Benedict,[8] who found that the effort of complicated mental arithmetic increased metabolism 3 to 4 per cent during the short periods it was carried on, compare the relative effects of mental and muscular work as follows: "The professor absorbed in intense mental effort for an hour has an extra demand for food or for calories during the entire hour not greater than the extra need of the maid who dusts off his desk for five minutes."

Growth, Pregnancy and Lactation. With most adults the desire is to have the fuel intake just about balance the energy requirement so that the weight will be maintained constant. With children, on the other hand, it is important to provide energy OVER AND ABOVE that required for the internal work of the body and for muscular activity, in order that additional material may be available for increasing the body weight in **growth.** Rapidly growing infants have been shown to be storing 12–15 per cent of the energy value of the food taken. This extra energy is stored in the form of newly built tissues. As growth becomes less rapid, though the total food

[8] Benedict, F. G., and Benedict, C. G., "The Energy Requirement of Intense Mental Effort," Science, v. 71, p. 567, 1930.

requirement is more because of the increased size, the allowance needed per unit of body weight becomes smaller (see table on p. 459). Adults recovering from a wasting illness also require extra energy for building new tissue. In pregnancy there is also need for energy to build new tissue, and in lactation to provide for the energy value of the milk secreted.

More detailed information concerning the special dietary needs of children and pregnant or nursing women will be found in Chaps. 26 and 27 (pp. 457 and 483).

SUMMARY

In order that the foregoing enumeration and brief discussion of the many different factors which influence the energy requirement of the body may not leave the reader in a confused frame of mind, it seems desirable to show concretely how these factors work together to determine whether the energy need will be high or low in a few definite and contrasting types of individuals. In the above analysis of the factors, we have pointed out which ones have the effect of increasing and which of decreasing energy metabolism, and why. Now we shall endeavor to show how under certain conditions all the factors which are operative seem to combine to force up the energy needs, while in opposite circumstances they act in such a way that the energy requirement will be unusually low. The reader should then be able to predict whether the energy need will be relatively high or low in a given person, according to the class in which he or she falls.

Tall, Slender Type. All the following factors act to increase energy metabolism so that energy needs are **high**:

(1) Relatively large amount of more active tissues.
(2) Relatively large amount of surface area.
(3) Absence of layer of subcutaneous fat.
(4) Temperament high strung; muscle tonus high.
(5) Active; do a good deal of muscular work.
(6) May have slightly overactive thyroid which results in rather high basal metabolism.

Short, Fat Type. All the factors act to depress the energy needs, which are hence relatively **low**, as follows:

(1) Less active tissue and more inactive tissue (fat).
(2) Less surface area, in proportion to weight.
(3) Well-developed layer of subcutaneous fat acts as insulator.
(4) Temperament easy-going; muscle tonus less.
(5) Inactive; take little exercise.
(6) May have slightly underactive thyroid which causes a low basal metabolism.

Sedentary Persons. The energy requirement is apt to be **low** for the following reasons:

(1) Little energy is needed for doing external or muscular work.
(2) When inactive, the internal processes of the body are somewhat more sluggish.

Muscularly Active Persons. The energy requirement of such persons is **high** because

(1) The external work which they do requires a large amount of energy.
(2) When much exercise is taken, the body processes (heart beat, breathing, muscle tonus) are more active.

In Youth. The energy needs of infants and children are especially **high** for the following reasons:

(1) The surface area is proportionally large in smaller bodies.
(2) There is an especially high basal metabolism in youth.
(3) Children use much energy in muscular activity.
(4) There is need of considerable extra energy to allow for building new tissue in growth.

In Old Age. Energy needs are somewhat **lower** in aged persons than in younger adults because

(1) The internal processes are a little slower in old age.
(2) The amount of energy used for muscular activity is usually decidedly less.

QUESTIONS AND PROBLEMS

1. In comparing the basal metabolism of adults, will it be more constant when compared on the basis of unit of surface area or body weight, and why? What four factors have the most important influence on basal metabolism? Name four other factors that have lesser influence. Fill in the blanks in the following statements with the words "higher" or "lower," whichever would be true in the given case, and give reasons for your answer.

Basal metabolism per unit of body weight (kg. or lb.)
will be ——— in a 2-year-old child than in a 20-year-old woman.
will be ——— in a woman than in a man of the same age.
will be ——— in a tall, thin man than in a short, fat man of same weight.
will be ——— in a person when asleep than when awake but lying quiet.
will be ——— in the same person when relaxed than when muscularly tense.
will be ——— in a patient with exophthalmic goiter than in a person with normal thyroid gland.

2. What three factors increase the total energy needs above the basal requirement? Which two are operative in practically all cases, and under what circumstances does the third factor assume importance? Which factor has by far the largest effect quantitatively? Suppose that a man is sitting in the station quietly; he suddenly realizes his train is about to leave and makes a run for it; after the run that lasted two minutes, he relaxes in seat on train. If he uses 100 calories per hour sitting at rest, and 570 C. per hr. while making his dash for the train, how many calories would he use in the 2 min. run? Would his energy metabolism return at once to 100 C. per hr. when he took seat on train, and if not, why not?

3. Assume that each of the following persons has a basal metabolism of 1 calorie per kg. per hr.—a woman who weighs 56 kg. (123 lbs.), a man of 65 kg. (143 lbs.) weight, and a man of 75 kg. (165 lbs.) weight. Assume that the woman needs 500 C. to cover her muscular activity, the first man 650 C., and the second man 2,300 C. for the same purpose (since he does 8 hr. of muscular work). Assume that each needs 6 per cent of the total calories used in basal metabolism plus muscular activity added to cover the effect of food. Calculate the total calorie needs per day of each of these individuals (basal metabolism plus allowance for activity, plus allowance for cost of food).

	Sedentary woman, 56 kg. wt., C.	Sedentary man, 65 kg. wt., C.	Muscularly active man, 75 kg. wt., C.
Basal metabolism (1 × 24 × wt. in kg.)			
Allow for muscular activity	500	650	2,300
Allowance for energy cost of food			
Total daily energy needs			

4. Make a record of your own activities for a sample day, classifying them as nearly as possible under the headings of activities given in the table on p. 142. Figures given in this table for energy used in different activities include an allowance for basal metabolism and effect of food, so these do not have to be reckoned separately. Group sitting activities, those that involve standing or walking about room, those that require light or moderate exercise, and select nearest comparable figure in table for calories per hour for each, using either per lb. or per kg. column as desired. Add energy required (per unit of weight) for 24 hours and multiply by your weight in kg. or lbs., whichever factor was used as weight unit in table. This gives your approximate energy requirement per day.

5. Make a record of your food intake for one day (including all food taken between meals). Using the table in Appendix for calorie values of common foods in average servings or common measures, calculate your calorie intake for one day. How does it compare with your energy requirement? Would you expect to gain or lose weight, or to maintain present weight under these conditions?

6. Describe the methods by which heat loss is brought about by physical means. What happens when chemical regulation of body temperature is called into play, and under what circumstances will this be necessary? Why was it not necessary in the calculations of energy needs in above questions to make any allowance for energy to maintain normal body temperature? For mental activity?

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CHAPTER 10

THE PROTEIN REQUIREMENT

IN ADDITION TO meeting energy requirement of the body, food should also supply amounts of the various BUILDING MATERIALS sufficient for body needs. Chief among the materials needed to build tissues is PROTEIN. Muscles and bone are the two most abundant tissues of the body. The nervous tissue forms only about 2 per cent of the body weight, while the skin, cartilage, tendons, etc., also constitute but a small proportion of the whole. Fatty tissue is present in varying amounts.

Protein is an essential part of EVERY CELL in the body (see p. 43) but is present in relatively small amounts in the inactive tissues, bone and fat. The bulk of the active tissue in the body is made up of the muscles, both voluntary and involuntary, and by far THE MOST PROMINENT SOLID CONSTITUENTS OF MUSCLE TISSUE ARE THE PROTEINS. "Muscle contains about 25 per cent of solid matter, of which four fifths is protein material and the remaining one fifth extractives and inorganic salts."[1]

Protein Needs in Adult. It should be self-evident then that a supply of protein would be necessary for the building of new tissue, especially of new muscular tissue. But the building of new tissues is chiefly confined to the growth period or earlier years of life. How about the needs of the adult for this building material, protein? Only under exceptional circumstances is the adult called upon to BUILD NEW TISSUE, namely in PREGNANCY and LACTATION, in recuperation after WASTING ILLNESS, and for MUSCLE GROWTH that results from exercise. In such cases the adult needs an EXTRA supply of protein just as the child does.

But even the adult who is not building any new tissue needs some protein supplied in his food, in order to provide for the REPLACEMENT necessitated because of the wear and tear of the life processes on his tissues. While it is scarcely true, as most people believe, that every cell in the body dies and is replaced within a seven year period, still there are constantly some casualties among the cells. Also the breaking down activities within the living cells result in changes which call for continual replacements of

[1] Hawk and Bergeim, PRACTICAL PHYSIOLOGICAL CHEMISTRY, 11th Ed., P. Blakiston's Son and Co., p. 223, 1937.

material. This replacement or "repair quota" is naturally rather small in comparison with the "growth quota" of protein needed in childhood, but it is not inconsiderable and is absolutely indispensable to the well-being of the adult.

Smaller amounts of protein, or of special amino acids furnished by proteins, are needed for purposes other than actual tissue building—for the making of enzymes that are essential for digestion and oxidative processes in the tissues; for making such potent hormones as those of the thyroid gland (thyroxin), adrenal glands (adrenalin) and pancreas (insulin); for building the antibodies that help ward off infectious diseases; and for the protein part of hemoglobin, the oxygen-carrying pigment of the blood. It has also been shown recently that certain amino acids give rise to nitrogen-containing extractives, such as carnosine and creatine in muscle tissue. The amino acids supplied by protein are thus essential to the welfare of the body in many ways.

Conditions Which Determine the Amount of Protein Required. The main uses of the body for protein will be

(1) For **building new tissues** in { **growth** (childhood). **pregnancy** and **lactation.** building up of adult after wasting illness or in athletic training.

(2) For **up-keep of tissues** already built.

The **amount** which is needed for these purposes will naturally depend upon the extent or rapidity of these processes. For instance, in the rapidly growing infant as much as one-third of the protein of the food may be retained for building new tissue. As growth becomes less rapid, the percentage of the protein intake that is retained in the body for tissue building will be less, but a plentiful supply of high quality protein is necessary throughout the growth period in order to secure the best possible growth and development. In the later months of pregnancy and in lactation, an extra quota of protein is also needed.

When there has been excessive breaking down of the tissues, as in starvation or wasting illnesses, there will be a need for extra protein for tissue repair or rebuilding. This has long been realized in the diets given to build up patients after prolonged fevers or those who are chronically undernourished. In the recent pitiful cases of half-starved persons, those rescued from prison camps or civilians in war-ravaged lands, predigested proteins were given at first, followed by mixtures of dried eggs and milk (foods rich in high quality proteins). Similar diets have also been said to hasten recovery from wounds and extensive burns.

But the protein requirement of the normal adult is relatively small and constant. He cannot store protein to any extent and needs from day to day only enough for the maintenance of tissues already built.

Further factors that have an influence on the quantity of food protein which will be necessary to meet the body needs are—

(a) SIZE OF THE BODY.
(b) NATURE OF THE PROTEINS EATEN.
(c) COMPLETENESS OF DIGESTION AND ABSORPTION.

Size is an important factor. The protein required for tissue up-keep would naturally be less for a small body than for a large one. The high protein requirement of infants and children is all the more striking when one remembers that their protein needs are chiefly for growth, while the amount needed for maintenance of their smaller bodies would be less than in the adult. Since protein needs are dependent on the total amount of active tissues, we reckon the protein requirement as so much per unit of body weight.

In Chapter 4, pp. 45 to 48, it was explained at length that NO TWO PROTEINS ARE EXACTLY ALIKE IN COMPOSITION, since proteins are made up of a number of different amino acids, which may be combined in a great variety of ways and in different relative amounts. Some proteins have one or more necessary amino acids either entirely lacking or present in very small amounts (incomplete or partially incomplete proteins). It should be apparent that **different proteins** are **not interchangeable** for meeting the protein needs of the body. Certain INCOMPLETE proteins, like gelatin and those in navy beans, would never be adequate ALONE to provide for the body's need for protein (see Fig. 9B, p. 48) no matter how large an amount of them were eaten. The amino acids which they do provide can of course be used, when they are taken in conjunction with other proteins that supply a goodly amount of those amino acids which the incomplete proteins lack. With suitable combinations of proteins in the diet, the different proteins thus supplement each other in meeting all the needs of the body for the various essential amino acids.

The factor of **digestion** and **absorption** is ordinarily not a large one, though it should be evident that proteins like those of the legumes, which are less completely digested and absorbed than most proteins, are slightly less efficient for meeting the body's protein needs on this account. A protein is of no good to the body until it has been split into its constituent amino acids by digestion, and until these amino acids are absorbed and carried to the tissues. However, the loss due to imperfect digestion and

absorption normally does not amount to more than 5–10 per cent. Proteins are less completely digested and absorbed when they occur in foods mixed with much indigestible fiber or cellulose (as in peas and beans); protein in tough cuts of meat is slightly less well utilized, unless the fiber is properly softened in cooking. This factor may be of greater importance when abnormal conditions arise in the digestive tract that greatly limit the digestion and absorption of food. In some such extreme cases predigested protein (or amino acid mixtures) may be given.

Essential Amino Acids and Biological Value of Proteins. Recent research[2] has established just which ones of the 21 commonly occurring amino acids must be furnished preformed in the food and which ones can be made in the body from related substances. An amino acid is said to be "nutritionally essential" or "indispensable" if it "cannot be synthesized in the body out of materials ordinarily available at a speed that will supply the demands for normal growth." For rats ten different amino acids must be supplied in adequate amounts in the food, but for man only eight of these have been shown to be "indispensable." The other amino acids are said to be "dispensable" in that they will be made in adequate quantities, chiefly from materials in protein foods. Obviously it is important to know that the proteins in the diet are in such amount and of such kind as will furnish the necessary quantity of essential amino acids, along with various nonessential ones. The names of the amino acids known to be essential for man are:

Lysine	Leucine
Phenylalanine	Isoleucine
Tryptophane	Threonine
Valine	Methionine

Two others, arginine and histidine, are required by rats and there is some question that the former may be needed by men. While the student need not memorize the names of these amino acids, they are so much talked about now that their chemical names are almost as commonly heard as are those of the vitamins. That they are just as vital for well-being as vitamins are can be seen from the pictures in Figure. 7, p. 46.

Proteins that have a balanced amino acid make-up and furnish good amounts of all the essential amino acids are said to be of high "BIOLOGICAL VALUE"; those that are low or lacking in one or more of the essential

[2] Rose, W. C., "The Nutritive Significance of the Amino Acids," Physiol. Rev., v. 18, p. 109, 1938 and "The Role of Amino Acids in Human Nutrition," J. Biol. Chem., v. 146, p. 683, 1942 and idem, v. 148, p. 457, 1943.

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amino acids are of lower biological value, although they may be useful in the diet in conjunction with some complete proteins. This is shown by the content of casein (a complete protein from milk) and zein (an incomplete protein from corn) in six of the essential amino acids,[3] as given below:

	Casein *per cent*	*Zein* *per cent*
Lysine	6.3	0.0
Phenylalanine	3.9	7.6
Tryptophane	2.2	0.0
Leucine and isoleucine	9.7	25.0
Valine	6.7	1.9
Cystine	0.3	1.0

Zein would not do as the sole protein in the diet since it is totally lacking in lysine and tryptophane, but it furnishes an unusually high quota of leucine and isoleucine. Casein is a complete protein but it contains only small amounts of cystine which, although not one of the essential amino acids, must be supplied or made in the body to support growth; zein has a higher content of cystine, so in this as well as in other respects the two proteins supplement each other in amino acid content.

When a protein is very low in some one amino acid, this is a "limiting factor" in its usefulness for growth or maintenance, since the extent of tissue building is limited by the smallest amount of any necessary tissue constituent that is available. If fed as the sole protein, much more of it must be supplied to produce normal weight gains than would be needed if the amino acid make-up were better balanced. Lactalbumin (a second protein in milk) is the most efficient protein yet found; only 8 per cent of lactalbumin in the diet produced the same gain in weight as 12 per cent of casein and 15 per cent of edestin (a complete protein found in nuts). Both suitable quality and quantity of the protein supply is necessary for growth.

The mixtures of proteins that occur in eggs, milk, cheese, meat, and most nuts are considered of high biological value, while those found in most cereal grains, legumes, and other vegetables are said to be of lower biological value. In order to be of high biological value, a protein must be well digested and absorbed, as well as of suitable amino acid content.

Muscular Work Not a Factor in Protein Requirement. Muscular work, which is the largest single factor in determining the energy needs, has no APPRECIABLE effect on the protein requirement. This fact is so surprising to many people, and the popular belief that muscular tissue is in

[3] Casein and zein contain numerous other amino acids besides the six listed as examples here.

some way broken down when work is done, is so persistent that it seems best to give a special paragraph to the contradiction of this erroneous impression. Probably no two physiological errors are more deeply rooted in the popular mind than the ideas that MENTAL work raises the ENERGY needs of the body (see pp. 134 and 142), and that MUSCULAR work is done at the expense of PROTEIN material. Scientists themselves taught these theories in an earlier generation, but they have long since been disproven by scientific evidence.

We now know that the fuel which is oxidized to provide energy for work is CARBOHYDRATE instead of protein. While both fat and protein can serve indirectly as fuel for muscular work IF NECESSARY, they probably have to be built over into intermediate products of carbohydrate metabolism before the muscle can use them. Protein especially is only used as fuel for work when other material is not available, since it is indispensable for the building and repair of tissues.

If the layman would stop to think of it, he would recognize the fact that the muscles of the athlete or laboring man do not appear reduced in size, when severe muscular work is done regularly. The carbohydrates and fats in the diet, if eaten in sufficient quantities, serve to supply most of the energy for the work; the muscles, instead of being consumed, are in such healthy condition as a result of the habitual exercise that they take on new firmness and are actually built up somewhat in size. While there are no grounds for the idea that a laboring man or athlete requires an extra amount of meat because he is doing much muscular work, he does require more fuel foods and protein is an integral part of so many foods that increased food consumption usually means an increased protein intake. However, to prevent exhaustion from severe muscular work carbohydrate is the most efficient foodstuff.

Minimum Requirement for Adults. It may seem confusing to some people to be told that the body generally uses up (or metabolizes) an amount of protein considerably in excess of the quantity needed for tissue building and repair. This is mainly due to the fact that it CANNOT STORE PROTEIN, at least in any appreciable amounts. Hence, the protein that is eaten over and above the amount actually needed MUST be burned up and the products of this oxidation excreted. There is one quota of the protein intake which is used directly for the building or repair of tissues, *i. e.*, the digestion products of the protein are withdrawn from the blood stream and built up into tissue protein material. For this purpose the amino acids (into which the proteins have been broken down during digestion) are kept intact and their characteristic element, nitrogen, is not split off from

them but is incorporated into tissue protein and a small amount used to make enzymes and hormones, etc. We now know, from experiments with amino acids, which are "tagged" by containing an isotope atom that is easily detected, that there is free exchange of amino acids between living tissue protein and amino acids in the blood stream and tissue fluids. The amino acids thus kept intact for use in the protein tissues of the body represent the **protein requirement,** or the quantity actually NEEDED by the body. This has been estimated by Sherman[4] at about 44 grams per day for a man of average weight, or 0.5 GRAM PROTEIN FOR EVERY KILOGRAM (2.2 lbs.) of body weight. Other estimates[5] place the minimum requirement of the adult for protein at an even lower level (about 20 gm. for a 70 kg. man) provided the proteins given present an assortment of amino acids very similar to that needed by the body tissues. According to the estimate of 0.5 gm. protein per kg. body weight, a 70 kg. (154 lb.) man would require 35 gm. daily. Few of us would care to live on the minimum level of protein requirement, nor is it advisable to attempt to limit protein intake so strictly.

Protein Metabolized. The second quota of protein used consists of all the **extra protein eaten** over and above the amount needed for tissue-building and repair. The fate of this excess protein is that the nitrogen is split off and worked over into certain nitrogen-containing substances which are thrown off by the kidneys, while the remaining non-nitrogenous fragments are burned or oxidized, just as the digestion-products of carbohydrates and fats are subjected to combustion in the body. The nitrogen, which is an indispensable asset as long as protein is used for tissue-building, becomes a liability when it is necessary to burn up protein as fuel. It has even been compared to the incombustible cinders which clog a grate. This is one of the reasons why protein is said to be an uneconomical and disadvantageous form of fuel.

The **quantity of protein metabolized,** or burned up in the body in a day, will thus depend, generally speaking, upon two main considerations—

(1) The LEVEL OF PROTEIN CONSUMPTION, and

(2) The NECESSITY TO BURN PROTEIN FOR FUEL, due to having an inadequate supply of carbohydrate or fat for this use.

1. The amount of protein eaten varies widely with personal preferences and race habits. The average American or European man prefers to eat about 80–100 grams of protein daily. The Eskimo, who has little except

[4] Sherman, H. C., Jour. Biol. Chem., v. 41, p. 105, 1920.

[5] Martin, C. J. and Robinson, R., Biochem. J., v. 16, p. 407, 1922.

Terroine, E., Quart. Bull., Health Organization, League of Nations, v. 5, p. 427, 1936.

meat available for food, may consume in his diet and burn up in his body as much as about 300 grams of protein daily without apparent harm. Dwellers in the tropics, where carbohydrate foods (fruits and vegetables, rice, etc.) are so much cheaper and more plentiful than other foods that a low-protein, vegetarian diet is frequently the custom, may be maintained in good health on a protein intake of not more than 50 grams per day. The body thus adjusts the amount of protein which it burns to fit the level of its protein intake, since all protein that is taken over and above the minimum required for maintenance will be burned up.

Whatever the level of protein intake, the amount burned or metabolized in the body TENDS TO BALANCE IT, since protein cannot be stored. On changing from a high protein diet, however, to one that contains a lesser amount of protein, there is always a few days' lag during which the body gradually adjusts its protein consumption to the lowered level of protein intake. There is likewise a short delay in adjusting the balance between consumption and intake on changing to a higher protein level.

2. The extent to which protein must be burned for fuel depends on how completely the energy needs of the body can be met from the amount of carbohydrate and fat immediately available as body fuel. Protein may be thought of as an emergency fuel to be drawn upon when the supply of carbohydrate and fat is inadequate to meet the necessary expenditures for energy. Thus in starvation, after the small amount of stored carbohydrate is used up and the reserve stores of fat are partially exhausted, the body begins to burn protein for fuel. Similarly, a man who does much muscular work, or is inadequately clad in a cold room, will use some protein as the fuel needed to produce work or heat, PROVIDED THE AMOUNT OF CARBOHYDRATE AND FAT AVAILABLE IS INSUFFICIENT TO FURNISH THE ENERGY REQUIRED. Carbohydrates and fats are both spoken of as being "protein sparers," since the presence of a liberal quantity of these foodstuffs in the diet does away with the necessity of using protein for fuel. Carbohydrates serve better in cutting down the amount of protein burned than do fats.

It is especially important that CHILDREN should take sufficient carbohydrate and fatty food so that they will not be obliged to burn for fuel protein which might be used to much better advantage for building new tissue material during the growth period. Or to put it the other way around, children can make the best growth ONLY when their food supplies both a liberal quantity of protein, which furnishes all the amino acids needed for tissue building, and IN ADDITION, an amount of carbohydrate and fat entirely adequate to cover their energy needs.

Standard Allowance of Protein. This term means the quantity of protein which is recommended by most current authorities as the safest amount to include in the daily diet. A very high level of protein consumption is not encouraged because it is expensive (most protein-rich foods are relatively costly), is of no permanent value since the excess must be burned up, and may be unwise since the excretion of extra nitrogenous waste products makes unnecessary work for the kidneys. On the other hand, too low protein intake may lead to nutritional edema (bloating caused by higher water content of tissues), lessened vitality and physical stamina in adults, and stunted growth in children. In a survey of the rural population of Tennessee,[6] symptoms indicating a tendency to nutritional edema were found in one person in every five, while a dietary survey of 1000 adults in New York City[7] showed that 60 per cent ate less than 42 gm. of protein per day. Too little protein may thus be a real health hazard. Since it is important that the various proteins of the mixed diet should supply adequate amounts of all the essential amino acids, most authorities now favor the inclusion of a MODERATELY LIBERAL AMOUNT OF PROTEIN in the diet as a "FACTOR OF SAFETY" to insure maximum growth and sustained vigor.

Such a factor of safety is provided in the daily allowances of protein recommended by the Food and Nutrition Board of the National Research Council in 1948, namely

Men	70 gm. protein, or	1 calorie per kg. body weight
Women	60 " "	" " " " " "
Children[8]		
Under 1 year		3.5 " " " " "
1– 6	40– 50 " "	
7–12	60– 70 " "	
13–20		
Girls	75– 80 " "	
Boys	85–100 " "	

These allowances for adults are about double the minimum required for maintenance, which means a factor of safety that will cover variability in biological value of the proteins eaten and any losses in digestion and absorption. With children, although the total protein may be less for those of smaller weight, the proportion per unit of weight is high to allow plenty

[6] Youmans, J. B., Am. J. Pub. Health, v. 31, p. 704, 1941.

[7] Ashe, B. I., and Mosenthal, H. O., J.A.M.A., v. 108, p. 1160, 1937.

[8] Varies with weight and rapidity of growth; lower allowances are for the younger ones of lesser weight, except for rapidly growing girls (13–15 years) when 80 gm. is recommended.

for protein storage in growth. Note that the allowance per kilogram (2.2 lbs.) weight is $3\frac{1}{2}$ times as much for the rapidly growing infants as for the full grown man.

How to Secure Protein Allowance in Diet. It is possible to secure about the correct proportion of protein in the diet, as well as a suitable mixture of proteins to provide liberally all the amino acids necessary for maintenance and growth, without the burdensome task of figuring out from tables the total number of grams of protein or of calories eaten and the percentage of these calories furnished by protein. In planning the diet, it is wise to keep in mind which foods contain considerable protein, which contain complete proteins (lacking in no essential amino acids), and which contain SOME proteins that are either wholly or partially incomplete. A list of protein foods with the types of protein that they carry follows.

Food Materials	*Kinds of Protein Present*
Milk, Cheese, Eggs, Lean meats	2 complete proteins
Wheat, Corn, Soybeans, Peanuts	1 complete and 1 incomplete protein
Beans, Peas, Gelatin	1 incomplete protein

Recommendations as to the best amount of protein to eat are sometimes stated in terms of a certain PERCENTAGE of the total number OF CALORIES TAKEN. It is generally agreed that if **10 to 15 per cent of the calories** taken are in the form of protein a suitable allowance of protein will be provided. In the case of growing children, it is only because the high protein requirement runs parallel with such a high energy requirement per unit of body weight that the relative proportion of protein in the diet does not need to be increased much, if any, above that allowed for adults. In human milk only 9 per cent of the calories is furnished by protein, but much of this is the highest quality protein, lactalbumin. Cow's milk contains less lactalbumin and more casein but carries about 19 per cent of its calories as protein. Thus a young child who gets plenty of milk will usually get plenty of good quality protein, though perhaps it is safer to allow 15 per cent of the calories in protein for children. A 2–3 year old child who needs 1200 calories would have an allowance on this basis of 45 gm. protein (1200 ×

0.15 = 180 ÷ 4 = 45). A sedentary man or moderately active woman, who took 10 per cent of the 2500 calories required in the form of protein would be getting 62.5 gm. protein (250 ÷ 4).

These recommended allowances are not intended to be taken as hard and fast rules. They suggest a minimum that allows for a factor of safety, especially when a considerable proportion of it comes from proteins of high "biological value." If the foods taken are chiefly those that carry proteins of lower biological value, the total protein intake should be more liberal. Quality of protein influences the quantity needed and a moderate excess over actual needs will do no harm.

For the average ADULT sufficient protein of excellent quality will be insured if the following foods are included in the dietary every day—

Milk, 1 pint (2 glasses)
1 serving meat
1 " other protein-rich food
} furnishing 45–50 gm. protein

The serving "other protein-rich food" may consist of
1 egg, or
½–¾ c. legume, or
2 tbsp. peanut butter, or
1 rounded tbsp. cottage cheese, or
1 oz. American cheese, or
1 serving leftover meat dish

Grain products and other vegetable foods as usually taken AD LIBITUM may be relied upon to provide about 20 grams protein, which will make up the protein ration to 65–70 grams, or about the allowance for the average adult.

For CHILDREN, Sherman[9] states, "With an optimal amount of milk in the dietary of the growing child, the other foods may be selected with primary reference to other qualities than their protein content; without a liberal use of milk the proper feeding of a growing child becomes a very difficult problem, even more with respect to mineral and vitamin than to protein needs." The fairly liberal use of eggs and an occasional serving of meat, taken together with the proteins contained in lesser amounts in other foods, will generally raise the total protein in the diet of a child to about 15 per cent of the total calories, when the quart of milk per day rule is adhered to. The slightly higher proportion of protein in the diet of children and the inclusion of a larger amount of those foods which contain the most efficient proteins for promoting growth are considered wise safeguards during the growth period.

[9] Sherman, H. C., CHEMISTRY OF FOOD AND NUTRITION, 7th ed., Macmillan, p. 217, 1946.

In the United States, where meat, eggs and dairy products are plentiful, it is estimated that at least half of the protein in the usual diet comes from animal foods. Many other countries are not so fortunate in the amount of animal proteins available, in fact there would not be enough animal foods in the world to allow everyone to get 50 per cent of their protein needs from proteins of animal origin. The distinction between animal and vegetable protein is not so much stressed now as formerly, for we know that vegetable foods such as cereal products, legumes and nuts contain complete proteins along with some that are incomplete, and that they can safely make up quite a high proportion of the diet, especially if supplemented with some high quality protein such as found in milk. The proteins of milk are particularly valuable for supplementing the vegetable proteins and providing a mixture of amino acids that is favorable for maintenance and growth when the diet is low or lacking in meat and eggs, as in so-called vegetarian diets. One protein supplements another in the mixed diet, and the important thing is that the diet as a whole should provide adequate amounts of all the essential amino acids.

QUESTIONS AND PROBLEMS

1. What factors determine the need of the body for protein? Explain the difference between these terms and the meaning of each—minimum protein requirement, standard allowance of protein, actual protein intake, protein storage, metabolized protein.

2. How and why do the protein needs of children differ from those of the adult? Under what special circumstances does an adult require extra protein for tissue building or repair? Why does the quality of the protein taken influence the quantity that is needed? What proportion of the protein in the diet of children should be high quality protein?

3. Discuss what is meant by the biological value of a protein. What factors determine its biological value? How many amino acids must be furnished preformed in the food of man? What will happen if these amino acids, or any one of them, are provided in less than adequate amounts?

4. Weigh yourself and calculate your weight in kilograms (2.2 lbs. = 1 kg.). Allowing 1 gram of protein for each kilogram of body weight, what should be your daily protein allowance? Why is the protein allowance based on body weight? If the actual requirement for protein is only about 0.5 gm. protein per kg. weight, why is the protein allowance twice that amount?

5. Record your food intake for 1 day. What protein-rich foods and how much of each did you take? Using the table of nutritive values of foods in

the Appendix (pp. 554 to 567), compute how many grams of protein your day's diet provided. Compare this with your standard allowance for protein and, if your protein intake was as much as 20 per cent lower than that recommended, make suggestions as to how to bring the level up to the desirable one. Does it matter if you are eating more protein than the standard allowance? If so, why; if not, why not? What are the disadvantages of overeating or undereating as to protein?

6. Which of the foods in your day's diet record furnished complete or high quality proteins, which foods contained some incomplete proteins? What percentage of your day's protein was in the form of high quality proteins? How were the incomplete proteins useful? Why can they not be depended upon as the sole sources of protein in the diet?

*7. Arrange a list of the chief protein-bearing foods in order of their relative costliness. Plan a low-cost diet for one day that will furnish 60–70 grams protein (adult allowance) using the following as a nucleus:

1 pint of milk
2 oz. serving of lower cost meat
2 servings other protein-rich foods of lower cost

Fill out the menus with enough bread, cereals, potatoes, and other low-cost vegetables to make up the protein allowance. Use tables given below.

*8. Plan a day's diet for a vegetarian, which excludes meat and eggs but includes milk and or cheese, and which furnishes 60–70 grams protein. Use tables below for protein substitutes for 1 serving meat and 1 egg.

Substitutes for

1 serving meat (3 oz.)	1 egg
1½ cups cooked dried beans or peas	½ cup fresh lima beans
1 cup cooked soybeans	¾ cup green peas
3 oz. American cheese	1½ tbsp. peanut butter or 3 tbsp. chopped peanuts
½ cup cottage cheese	⅓ cup (1½ oz.) chopped nuts
2½ glasses milk	1 oz. American cheese or 1 rounded tbsp. cottage cheese
	¾ glass milk

* It is suggested that half the class work out question 7 and the other half question 8.

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WHY THE BODY NEEDS MINERAL ELEMENTS, WATER AND FIBER

BODY COMPOSITION. The body is made up structurally of CELLS, TISSUES and ORGANS, but these in turn are all composed of different **chemical elements**, held together in many and varying forms of chemical combination. The chemical elements are thus the ultimate building stones of the human body, the composition of which may be stated as follows:

Human Body Composed of	Oxygen	65.0	per cent
	Carbon	18.0	per cent
	Hydrogen	10.0	per cent
	Nitrogen	3.0	per cent
	Calcium	1.5–2.2	per cent*
	Phosphorus	0.8–1.2	per cent*
	Sodium, Potassium, Magnesium, Sulfur, Chlorine	0.95	per cent
	Iron	0.004	per cent
	Manganese	0.0003	per cent
	Copper	0.00015	per cent
	Iodine	0.00004	per cent

* The amounts of calcium and phosphorus are variable, according to reserves of these two elements in bone. It is not settled as to what figures represent the average or normal values.

It will be seen that the element oxygen constitutes over half of the body by weight, while oxygen and hydrogen together make up three fourths of the body weight. The prominence of these two elements is largely accounted for by the fact that two thirds of the body weight consists of water, which in turn is made up of oxygen and hydrogen combined in weight ratio of 16:2. Oxygen and hydrogen are constituents of many other substances found in the body, especially fats, carbohydrates, and proteins. Carbon also figures prominently in the substances that occur in body tissues, while nitrogen and sulfur are essential constituents of body proteins. These five elements together account for over 96 per cent of body weight.

They are supplied to the body by carbohydrates, fats, and proteins in the food, and nitrogen is furnished only by proteins (which also supply sulfur together with some phosphorus and iron).

The remaining ten elements, listed in the table on p. 161 as constituents of the human body, are supplied to the body chiefly (in most cases exclusively) by the **mineral salts** or **ash constituents,** found mixed with or combined with proteins, fats and carbohydrates in foods as they occur in nature. Purified or refined food substances such as the pure fats, cane-sugar, corn starch and highly milled grains are practically free from ash constituents. As this term implies, these mineral elements make up the ash left after burning up the organic or combustible part of the food, but they may be present in the natural foods either as free mineral salts or held in combination with some of the organic foodstuffs.

Traces of other mineral elements are also found in the body—such as cobalt, zinc, nickel, silicon, aluminum, fluorine, bromine, and boron—but probably not all of them are essential for human nutrition. Cobalt has been proven indispensable (in minute traces) for maintaining normal nutrition in animals, while it seems probable that traces of zinc are also needed in the food of animals. Silicon and fluorine enter into the composition of bones and teeth.

These elements are each and every one essential to building tissue and to maintaining the life of the cells. Hence it is impossible to say that certain ones are more important than others, in spite of the fact that some are needed in much larger amounts than others, Indeed **iron** is one of the elements most vital for the well-being of the body, although it makes up only about 1 part in 25,000 in body weight, and the amount needed per day is naturally extremely small. This element is needed for making hemoglobin, the pigment in the red blood corpuscles which enables them to unite with oxygen and thus carry it to the tissues. The presence of small amounts of iron in the "chromatin" particles that exist in the nuclear part of cells, and in "cytochrome" in cell plasma, is also essential to the oxidative processes in the tissues themselves by means of which life is sustained.

Copper is now unquestionably accepted as essential for normal nutrition. It is indispensable in the process of forming hemoglobin, although not present in hemoglobin. Animals that get too little copper in their food will develop anemia, even though plenty of iron is supplied. However, copper is required in such small amounts and found in a sufficient number of foods, so that it is not likely to be lacking in the normal human dietary.

Iodine furnishes another instance of an element which is needed in very small amounts, but which is nevertheless essential. The body contains only $\frac{1}{100}$ as much iodine as iron, yet a certain amount of this substance is

indispensable for the manufacture of thyroxin by the thyroid gland (see p. 132) and an insufficient supply of thyroxin is manifested by profound disturbances of metabolism, such as are seen in goiter.

Manganese is another element which is present in small amounts in the body and is important for maintaining good nutrition, but manganese (like copper) is supplied in sufficient amounts by the ordinary mixed diet.

Calcium and **phosphorus,** on the other hand, are the two mineral elements most PROMINENT in the make-up of the body, and hence are the ones which need to be supplied in the most LIBERAL amounts by the diet.

Because of the nutritional importance of calcium, phosphorus, iron and iodine, and also because these four mineral elements are the ones that are most likely to be supplied in inadequate quantities by the diet, detailed consideration of these elements will be given in a separate chapter (Chapter 12).

NEEDS OF BODY FOR MINERAL ELEMENTS

It is our aim to give in a **table** (Table XII, p. 164) a clear, bird's-eye view of the uses which the body makes of mineral elements, and to accompany this with brief discussions of a few of the most outstanding instances of the need for these food substances and the difficulties that result from having an insufficient supply of them in the food.

Need for Ash Constituents to Build and Maintain Tissues. It was brought out in discussing protein requirement (p. 153) that there is a vital need for nitrogen to build new tissues during growth and to maintain those already built in the adult. Similarly there is a smaller but no less vital need for each of the eleven elements which we are discussing in this chapter (calcium, phosphorus, sulfur, chlorine, sodium, potassium, magnesium, manganese, iron, copper and iodine) as tissue-building material. This need is naturally larger in the child where a **growth quota** is needed for new tissue being built, but even in the adult there is a constant loss of small amounts of mineral elements, which may be taken as the **wear and tear quota** for these elements. Mineral salts are excreted for the most part by the kidneys in the urine, but considerable amounts of calcium and phosphorus may also leave the body in the feces. Iron is conserved by the body (metabolized iron is reabsorbed from the intestine) for reuse, but what little is excreted leaves the body mainly by the intestinal route. These losses must be made up by the mineral elements or ash constituents taken in the food unless the body is to become depleted.

Some of these elements are especially concentrated **in certain tissues** and hence are particularly important for the building and maintenance of

TABLE XII. NEED FOR MINERAL ELEMENTS

	Elements especially needed	Lack of these elements causes
***As* building materials.**		
Bones and teeth	Calcium and phosphorus	Stunted growth Weakened or soft bones Malformed or decaying teeth Rickets
Hair, nails and skin	Sulfur	
Soft tissues—chiefly muscles	All salts, esp. potassium, phosphorus, sulfur, chlorine	
Nervous tissue	All salts, esp. phosphorus	
Blood	All salts, esp. iron, calcium, sodium, phosphorus, chlorine	Lack of iron or copper (or both) results in less than normal amounts of hemoglobin in blood, a condition called nutritional anemia.
Glandular secretions	Stomach secretions—chlorine Intestinal secretions—sodium Thyroid secretion—iodine	Lack of iodine results in enlargement of thyroid gland, simple goiter.

	Elements especially needed
***As* body regulators.**	
To maintain *normal*	
(1) Exchange of body fluids	All salts
(2) Contractility of muscles	All salts, especially balance of calcium vs. sodium and potassium
(3) Irritability of nerves	
(4) Clotting of blood	Calcium
(5) Oxidation processes	Iron and iodine
(6) Neutrality of body	Balance between: Basic elements—sodium, potassium, calcium, magnesium and iron. Acidic elements—phosphorus, sulfur, and chlorine.

those tissues. In fact the bulk of the mineral substances in the body is concentrated in the skeleton or bony framework. It is because the chief mineral constituents of **bone,** upon which its rigidity depends, are compounds of the elements calcium and phosphorus that these two elements occupy so prominent a place quantitatively in the mineral composition of the body. If the body of a 150 lb. man were burned up as completely as possible, there would remain behind about 6 lbs. of ashes, a very large proportion of which would consist of calcium phosphate from the bones. About 99 per cent of the calcium and 90 per cent of the phosphorus in the body are found in the skeletal framework. Iron is concentrated in the red corpuscles of the **blood,** which are said to contain over 70 per cent of the body's total iron content. Iodine is found almost exclusively in the **thy-**

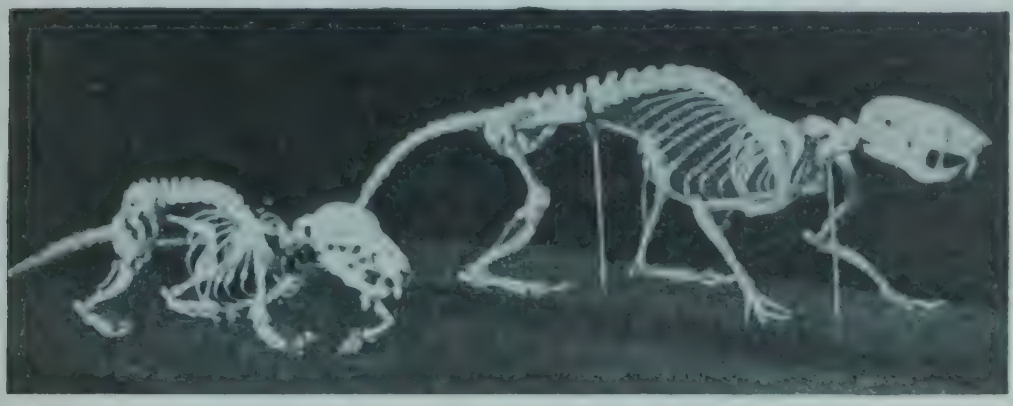


Fig. 15. Skeletons of twin albino rats showing influence of calcium content of the diet on the growth and character of the bones. The rat fed a diet adequate in calcium (right) attained full growth and had strong bones; the one on the left received a diet deficient in calcium; its growth was stunted and bones were soft, brittle and more or less deformed. (Sherman and MacLeod, Jour. Biol. Chem., v. 64, p. 429.)

roid gland and in thyroxin, the substance which it secretes and distributes through the blood to the tissues. Other elements are more evenly distributed among the various tissues of the body.

It must be remembered that EACH CELL CONTAINS SMALL AMOUNTS OF ALMOST ALL THE MINERAL ELEMENTS. Phosphorus in organic combination is an essential constituent of every cell nucleus and is especially abundant in nerve tissues; phosphorus-containing inorganic compounds (phosphates) are also present in considerable amounts in the blood and soft tissues. Sulfur is a constituent of certain amino acids used for building protein in tissues, as well as of substances (vitamin B_1, glutathione, etc.) that function in oxidation-reduction processes which in turn set free energy needed for life processes of cells. Salts that contain sodium, potas-

sium, calcium, magnesium and chlorine are also constant and important constituents of tissues and body fluids.

As a rule the body cannot store any considerable amount of the mineral elements, though some mineral reserves may be accumulated in the liver after a diet rich in these elements. If the diet is deficient in any of these elements over a sufficiently long period, the results of this shortage will nec-



Fig. 16. Destructive changes in jaw and teeth of guinea pig caused by prolonged mineral deficiencies in the diet. (Courtesy of Dr. Percy R. Howe, Forsyth Dental Infirmary, Boston.)

essarily be shown in some body damage in time. As relatively small amounts of these substances need to be supplied daily, the results of a diet deficient in mineral salts will not be apparent so quickly as the results of a diet deficient either in energy or in protein content. **Mineral deficiencies** will be more serious and will show up more quickly during the growing period or in pregnancy and lactation, when the quantities needed are larger. Those tissues which have a special need for certain elements will

naturally be the first to show the effects of an insufficient supply of those elements, *e. g.*, bone will suffer first from a lack of calcium or phosphorus, the red blood corpuscles from a lack of iron, and the thyroid gland from a lack of iodine.

The ordinary mixed diet will supply plenty of most of the mineral elements needed for upkeep of body tissues. Sodium and chlorine are furnished abundantly by salts in foods and by table salt (sodium chloride) added to the food. In cases where heat has caused profuse perspiration, with excessive loss of sodium chloride through the skin, the taking of extra salt in food or drinking water may help to avert weakness and symptoms such as seen in heat prostration. The need of the body for sulfur will be met if its protein needs are supplied, since most proteins contain sulfur. Potassium is a constituent of many foods, and is especially abundant in vegetable foods. Most of the mineral elements that are needed in very small amounts are widely distributed in foods, especially in unrefined plant foods.

Calcium and phosphorus are needed in such large quantities that the diet may furnish too little of them, especially for growing children, unless food is chosen wisely. Calcium is unevenly distributed in foods and some favorite foods are almost entirely lacking in it. The average American diet contributes enough iron but not much surplus, and some of the iron in foods is not readily utilized by the body. Less than optimum amounts of iodine in food and drinking water are a problem in certain areas. The special problems of how to get sufficient quantities of these four mineral elements will be taken up in detail in Chapter 12, p. 176.

Reproduction. Attention should also be called to the fact that disasters in reproduction are apt to occur when the diet is deficient in any necessary mineral salt. ALL THE VARIOUS MINERAL ELEMENTS ARE NEEDED IN LIBERAL AMOUNTS DURING THE PERIOD OF PREGNANCY to insure the proper development of the fetus and, if they are not provided in the food of the mother, the offspring will frequently be stillborn or so weak as not to survive long. The influence of diet on reproduction and directions as to diet in pregnancy will be more fully treated in Chapter 27.

Use of Mineral Salts in Regulating Body Processes. It is easier for most people to realize that tissues cannot be built without the mineral elements which are essential parts of those tissues, than it is to understand why mineral salts are necessary to the normal functioning of the body. The ways in which mineral salts act as **body regulators** were listed in the lower half of the table on p. 164, but require fuller explanation.

Perhaps the most familiar of these regulating actions of salts is the re-

lation between the salt content of the tissues and of the fluids which come in contact with them, in determining the amount of water which will be held back in the tissues or given up to the surrounding fluid. **Movements of water into or out of the tissues** are largely controlled by this factor. If the salt content of the tissues gets a little too high, water will pass from the surrounding fluid into the tissues to dilute the salt to its normal concentration; while if the salt concentration in the surrounding fluid is greater than it is in the tissues, water will be drawn out of the tissues. A crude illustration of how salts act in regulating the water content of the tissues is seen in the loss of weight, due to loss of water from the tissues, after the body has been immersed for some time in a strong saline bath. Conversely, there is often a dropsical swelling and gain of weight in kidney disease, due to water held back in the tissues when their salt content would otherwise become too high because of the inability of the kidneys to excrete salts in normal amounts. The absorption of water from the alimentary tract, the passage of water from the blood stream into the tissues or from the tissues into the blood, and the excretion of water from the body through the kidneys are all processes where the exchange of fluids is at least partially regulated by the relative amounts of salts present on the two sides of some body membrane.

We are not usually conscious of the part salts play in the exchange of body fluids unless conditions become abnormal, and the same is true as to their rôle in maintaining the **normal irritability of the nervous tissues and contractility of muscular tissues.** Neither muscles nor nerves will work right unless they are bathed in tissue fluids which contain a certain amount of salts and where the balance between the different mineral elements is as it should be. Calcium salts seem to have a stimulating effect, which tends to counterbalance the more or less relaxing or depressing effects of the salts of magnesium, sodium and potassium. Too much calcium salts in the blood may cause a state of tonic contraction of the muscles (rigor), while a spasmodic state of muscular tremors, called TETANY, results when the calcium content of the blood gets below a certain amount. Ordinarily the content of the different salts in the blood and tissue fluids is regulated to a nice balance and a constant level so that the muscles and nerves function normally. The rhythmic alternate contractions and relaxations of the heart muscle are an example of this regulation, and are dependent upon the maintenance of a normal concentration of all the necessary mineral salts in the blood.

It should also be noted that the presence of calcium salts in the blood is necessary to its clotting. The **clotting of blood** is a protective arrange-

ment to prevent undue loss of blood through cuts or hemorrhages. Persons whose blood does not clot as readily as it should and whose blood calcium is low, are given doses of calcium salts in preparation for an operation.

The importance of **maintaining body neutrality** has already been described at considerable length when discussing acid-forming and base-forming foods (pp. 84–86). Here again we have a condition essential to the body welfare, since the cells and enzymes in the tissues function best in a neutral or faintly alkaline medium, and the blood and tissue fluids are normally kept almost neutral (in reality, just on the alkaline side). This neutrality is in part dependent upon a balance between two opposing groups of mineral elements. The basic elements in the blood and tissues (sodium, potassium, calcium, magnesium and iron) are paired off against the acidic elements (phosphorus, sulfur, and chlorine) in forming neutral substances called salts. If the two groups just match up in amounts, a condition of neutrality results.

When either the basic or acidic elements predominate, other supplementary arrangements for regulating body neutrality in case of excess acidity or alkalinity are called into play, since this matter of maintaining neutrality in the blood and tissues is so vital to the body that there is a first, second, and third line of defense. (1) Proteins and the salts of phosphorus- and carbon-containing inorganic acids (phosphates and carbonates) act as buffer substances in blood and tissues, which means that considerable amounts of acid or alkali can be taken up by them without affecting the neutral reaction. (2) The body has a reserve acid (carbonic acid, which can be made from normal waste products, water and carbon dioxide, if needed) and (3) a reserve base (ammonia formed by the kidneys in case of need), which can be called upon in regulating body neutrality when an emergency arises. However, it will be apparent that in the long run the best interests of the body will be served by maintaining in the food such a balance between the basic and acidic elements as will make for body neutrality.

The essential part which the elements iron and iodine play in the **oxidative processes** of the body has also been stressed in the earlier sections which dealt with the need for these elements as building materials (pp. 162 and 163). It is scarcely necessary to point out that oxidation in the tissues could not go on at all except for the ability of the iron-containing hemoglobin to transport oxygen to the tissues in the blood, while iodine owes its rôle in oxidation to the ability of the iodine-containing thyroid secretion to speed up the RATE of the oxidative processes (see p. 132).

WATER

Water Losses. The fact that the water content of the body must be replenished from without to make up for continuous loss of this substance is a matter of such common knowledge that we need not dwell upon it here. Water is excreted from the body by the kidneys in the urine, by the lungs as water vapor in the expired air, and by the skin as sensible or insensible perspiration. Lesser amounts are regularly lost in the stools. The relative amounts which are excreted through these different channels vary somewhat, as is well known. Ordinarily more water is excreted in the urine than by other channels, but in hot weather a larger amount is thrown off in perspiration in the effort to regulate the body temperature (see p. 138) and a smaller volume of more concentrated urine is secreted. The amount lost through all channels averages 2 to $2\frac{1}{2}$ qts. per day.

Water Replacements. This loss must be made up by the water furnished from three different sources, namely

(1) By the fluids taken (water, beverages, soup, etc.).
(2) By the water contained in solid foods.
(3) By the water produced in the body as a result of the metabolic processes.

Solid **foods** contain a good deal of water—ranging from about 5 per cent in very dry foods like crackers to over 90 per cent in juicy fruits and vegetables like tomatoes, eggplant, cauliflower, lettuce, strawberries and watermelon. Even such a solid food as bread contains water to the extent of about 35 per cent of its weight.

Also many people do not realize that we form water in our own **tissues** as a product of the oxidative processes which are necessary to sustain life (see Chapter 19, on metabolic processes). Water is always one of the products formed when fuel foods are burned in the tissues to get energy, and this so-called "metabolic water" may amount to about a pint per day.

However, in addition to the water obtained from these two sources, we need to take **fluids** to replenish the water content of the body and the amount taken in this form should usually be about 5–6 GLASSES DAILY. If a good deal of milk, tea, coffee, or soup is taken one may not need to drink as large an amount of water as the quantity indicated above but, within reasonable limits, an excess of water intake over the actual need is a good thing. Taking too large an amount of water throws an unnecessary burden on the kidneys in getting rid of the excess. There is no objection to drinking water with meals, provided the amount taken is moderate and it is not

used to wash down the food. A moderate amount of water taken with or preceding a meal is an aid to digestion, since it promotes the secretion of gastric juice in the stomach. Large quantities of an iced beverage, however, slow down digestion and are harmful. Unless exceptionally hard, hard water is usually not injurious, but mineral waters may be harmful and should be taken only on advice of a physician.

SUGGESTIONS FOR WATER-DRINKING

One glass on rising	1
One glass before (or during) each meal	3
One glass in middle of forenoon	1
One glass in middle of afternoon	1
	6

Water as a Body Regulator. The FUNCTIONS of water in promoting body processes are chiefly based on its usefulness as a **solvent.** Most of the body materials except bone, skin, cartilage and fatty substances will dissolve in it. Since chemical reactions between substances cannot take place unless they are in solution, the materials of which the cells are made must be kept in solution in order that their life processes can go on. The fact that the protoplasm of the cells consists of approximately three fourths water has already been mentioned (p. 51).

Water is also very useful in keeping substances in solution in the gland secretions, circulating fluids, and excretions. It helps to promote the flow of **digestive juices** and dilutes the food taken. The digestive juices contain much water, most of which is reabsorbed from the intestine and used over again in the body. Soluble products of digestion are absorbed along with the water. About ten pounds of water in the **blood** is in use constantly to carry soluble nutrients to the tissues and waste products to the kidneys for excretion. **Urine** consists of 96 per cent water and 4 per cent solids, which have to be held in solution in order to be flushed out of the body.

One of the most conspicuous regulating activities of water is its rôle in **regulating body temperature.** It equalizes temperature by transporting heat from one part to another in circulating fluids. Its evaporation from the skin and lungs offers one of the best ways of getting rid of unwanted heat generated in the body.

Water as a Tissue-Building Material. Water is also, strictly speaking, a tissue-building material, even though it does not furnish any energy to the body. This is because water is a prominent and essential constituent of every kind of tissue, from a solid tissue like bone which is one-third water to a fluid tissue such as whole blood which consists of four-fifths

water. About 100 lbs. of a 150 lb. man's weight is due to the water contents of his body. One can see how necessary it is for growth and tissue upkeep that water be provided regularly.

FIBER

Vegetable FIBER, or CELLULOSE, is not a food material but it may be said to have a regulatory function in the diet. Since the human digestive tract is unable to digest and absorb cellulose, this substance can be of no use to the body as a whole. However, it is desirable, and indeed practically necessary, to have some indigestible residue left behind in the alimentary tract after the food substances are absorbed, and for this purpose it is essential that a suitable amount of cellulose or fiber be taken along with the food materials.

Cellulose or **vegetable fiber** should not be confused with **animal fiber** such as is found in meats. The latter consists chiefly of collagen, a protein-like substance which can be converted into gelatin, digested and absorbed. Hence, for indigestible fiber we have to turn to plant foods. This fiber is supplied chiefly in fruits, vegetables and the outer coats of grains.

Need for Fiber. Carbohydrates, proteins and fats are usually 90–98 per cent digested and absorbed, and the absorption of mineral salts and water is also fairly complete under favorable circumstances. If it were not for the indigestible substances taken in food, the **bulk** of material in the lower part of the intestine would be so small that there would be little **stimulus to the intestinal muscles** to move the residue along and procure evacuations of the lower bowel frequently enough to make for intestinal hygiene and the proper excretion of those waste products thrown off by way of the intestine. Moreover, the more active muscular contractions (peristalsis) of the upper intestine, which are stimulated by the presence of a considerable bulk of food, make for better absorption. Food residues do not have a chance to collect, stagnate and putrefy in the lower intestine, when the bulk of material is sufficient to cause active peristalsis in this section.

In addition to having sufficient bulk for the intestine to work on, it is necessary to maintain the **tone** of the intestinal muscles and to have sufficient **moisture** and mucus present in the intestine to lubricate the passage of the feces. Although the ingestion of considerable fiber is important, it is not the only factor that must be taken into account in order to avoid constipation (see p. 359).

How to Get It. Fiber is best obtained as an INTEGRAL PART OF FOODS. It is better to get cellulose in the form of **fruits, vegetables** and **whole**

grain foods than it is to take substances like bran or agar agar either separately or mixed with the food. In some instances the latter procedure may be necessary for short periods as a corrective measure, but adding bran regularly to a diet already rich in high residue foods is like "carrying coals to Newcastle" and may result in irritation of the intestine. If fruits, vegetables and thoroughly cooked whole grain preparations are given a prominent place in the diet (see rules for eating fruits and vegetables, p. 93), there will be no danger of a lack of indigestible residue in the intestine. Lists of typical low residue and high residue foods are appended.

Low Residue foods.	**High Residue foods.**
Sugar	Fruits (esp. if eaten with skins)
White bread	Vegetables (except potato)
Highly milled breakfast cereals, *e. g.*, cream of wheat, white farina, etc.	Whole wheat bread
Meat	Breakfast cereals from whole grains, *e. g.*, oatmeal, shredded wheat, dark farina, etc.
Potato	
Fats	
Milk	

QUESTIONS AND PROBLEMS

1. Name ten elements that are supplied to the body chiefly as mineral salts or ash constituents in the food (as contrasted with the elements supplied by protein, fat and carbohydrate). Which two of these are needed in largest quantities, and why? Which two are needed only in very small amounts but play an important part in facilitating oxidation in the tissues? Explain how these two elements function in tissue oxidations.

2. Why are mineral elements necessary for the building and upkeep of tissues? How does the quota needed for growth compare in amount with that required to repair "wear and tear" in the adult? Cite the conditions that may appear as the result of an insufficient supply in the diet in the case of each of the following elements: calcium, phosphorus, iron, copper, iodine. At what periods of life will a deficiency of mineral elements be most likely to occur, and why?

3. Name five ways in which the mineral elements act as regulators of body processes, and explain in each case how they function to bring about their regulating effects.

4. What proportion of each of the following tissues consists of water: blood, muscle, bone? Is water necessary for building and maintaining tissues? Name and discuss three ways in which water acts as a regulator of body processes.

5. By what routes is water lost from the body? What conditions determine the relative amounts of water lost through the skin and in the urine?

What conditions make for excessive loss of water from the body? What is the normal loss of water from the body daily (approximate)? Name three sources from which the body receives water to make good this loss. What is meant by water balance, and why is it important?

6. Why is vegetable fiber needed in the diet? Describe the effects of a diet that supplies too little fiber, of one that supplies too much fiber or harsh fiber that is irritating to a sensitive intestine. What foods are lacking in fiber and what types of foods furnish fiber abundantly?

7. It has been estimated that normal adults require about 4–7 gm. fiber per day in order to secure daily bowel movements. Given the following figures for fiber in foods, arrange a combination of foods that would introduce about 6 gm. fiber into the diet:

	Fiber, gm.		Fiber, gm.
Apple, 1 small	1.0	Beets, ½c. diced	0.9
Banana, 1 medium	0.6	Beet greens, ½c. cooked	1.4
Raspberries, ½c. canned	2.4	String beans, ¾c. cooked	1.4
Prunes, 4–5 medium	0.7	Carrots, ¾c. cubed	1.1
Strawberries, ½c. fresh	1.2	Peas, ¾c. fresh, green	2.2
Whole wheat bread, 3 slices	1.0	Oatmeal, ¾c. cooked	0.3
White bread, 4 slices	0.3	1 shredded wheat biscuit	0.6
		Cream of wheat, ½c. cooked	0.1

8. Keep a record of your total intake of water for one day, that is, the amount taken as water, soup, tea, coffee, and milk. How does your intake compare with the amount that most persons should take either in beverages or as drinking water?

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CHAPTER 12

FIVE IMPORTANT MINERAL ELEMENTS

THERE IS two to three times as much calcium and phosphorus in the body as all the rest of the mineral elements together. This is because these two elements make up so large a proportion of the bones, the structural framework of the body. Although both are present in smaller amounts throughout all the tissues and have many important uses (see pp. 164, 165, 168), by far the larger part of our intake of calcium and phosphorus (about 90 per cent of the calcium and 70–80 per cent of the phosphorus) is used for the building and upkeep of bones and teeth. However, the smaller amounts of these mineral elements in the blood and tissue fluids are important for the welfare of the whole body, especially for their action as regulators of body processes as described in the preceding chapter (pp. 168 and 169). Since calcium and phosphorus are so intimately associated in bone metabolism, they may be conveniently considered together.

CALCIUM AND PHOSPHORUS

Absorption. The absorption of calcium and phosphorus from food material in the intestine into the blood and tissues is less complete than that of such foodstuffs as carbohydrates, fats and proteins, since they often are present in compounds that are soluble with difficulty. It is the relative insolubility of calcium phosphate which makes this salt so useful for bone formation. These two mineral elements may occur in foods either in simple inorganic salts or in complex combinations as a part of organic foodstuffs. In the latter form, digestion must be completed before the mineral elements are absorbable. Many studies on the extent to which calcium in the food is absorbed or utilized under different conditions, indicate that the calcium absorbed ranges from 10 to 50 per cent of that ingested, varying with different individuals and as to whether conditions in the intestine were unfavorable or favorable for its absorption. Perhaps the average absorption of food calcium is about 33 per cent. Absorption of phosphorus is also variable, though usually it is somewhat better utilized than calcium. Contrast these figures with the 90–98 per cent utilization of carbohydrates.

fats and proteins in the food and you can appreciate that much of these mineral elements in the diet never even get into the body proper.

Since the salts formed by calcium and phosphorus are most readily soluble in solutions that are slightly acid, the ACID REACTION in the contents of the upper intestine which commonly prevails, due to the acidity of the digestive fluid secreted in the stomach, is FAVORABLE for their absorption. Any factor that renders the intestinal contents more alkaline, or that causes precipitation of calcium or phosphorus in INSOLUBLE form, will lower the absorption of these elements. For instance, large amounts of FAT in the diet will result in poor absorption of calcium through formation of insoluble compounds of calcium with fatty acids (soaps), and large doses of IRON salts will lower phosphorus absorption because insoluble combinations of iron and phosphorus are formed. Large amounts of FIBER, LAXATIVES or emotional upsets that increase frequency of bowel movements also tend to produce poor absorption of these and other mineral elements. The RATIO OF CALCIUM TO PHOSPHORUS in the diet also affects their absorption, since either element will be poorly utilized in the presence of relatively large amounts of the other. Better utilization takes place when they are furnished by the diet in approximately equal amounts.

The absorption of calcium and phosphorus is thus a complex affair, influenced by many variable factors. There is considerable difference of opinion as to how large a part the intestine plays in the excretion of these and other mineral elements, *i. e.*, whether the calcium and phosphorus found in the feces consists chiefly of unabsorbed food calcium and phosphorus or of these mineral elements that have entered the body previously and then been excreted into the "gut." For our purposes, this is an academic problem, since in any event the calcium and phosphorus in the "stools" represent quantities of these minerals unavailable to the body for its uses. A liberal supply of vitamin D acts in some way to increase the "net absorption" of calcium and phosphorus, while vitamins A and C (and perhaps other vitamins) also favor calcium absorption.

The relative amounts of calcium and phosphorus that are retained in the body vary with age, total intake, previous diet and other factors. Growing children naturally store more of these elements than adults, since they are building new bone, muscle and nerve tissue; also as the bones grow in size they should become richer in calcium as well. In general, more of these elements are stored in the body when they are provided liberally and in right proportions in the diet. Numerous experimenters have shown that children with a liberal supply of these elements may retain only about one fifth of the amount absorbed, though if the previous diet has been poorer in cal-

cium there may be an attempt to make up by storing more on the improved diet. In adults, mineral retention is small, perhaps about one tenth that of childhood. The exception is pregnant women who will naturally retain more calcium and phosphorus than other adults. An adequate supply of vitamin D is essential for maximum utilization of these elements, and there seem to be seasonal variations in calcium metabolism. All of these elements not retained are excreted, but the body has some ability to conserve them by excreting less in times of shortage.

Metabolism. Once they get past the barrier of the intestinal lining, calcium and phosphorus are carried in more soluble forms in the blood to all parts of the body and are available for the use of all tissues. However, by far the largest part of these elements used by the body is taken up by the **bones,** which constitute the **reserve stores** of calcium and phosphorus. A larger retention of these elements in bone makes for stronger bones and greater reserves of these elements for the rest of the body to draw upon in time of need.

Although BONE METABOLISM is relatively slow (there is a daily exchange of $\frac{1}{3}$ of 1 per cent of the protein in the body, as against $\frac{1}{8}$ of 1 per cent of the phosphorus and $\frac{1}{20}$ of 1 per cent of the calcium), calcium and phosphorus stored in the bones, especially that in the ends of bones (epiphyses), has been shown to be much more readily available for use in the body than formerly thought. RADIOACTIVE (tagged) phosphorus and calcium, when injected intravenously as salts, are found to be deposited promptly in bone, given up gradually to the blood plasma, and excreted over long periods (almost entirely in the urine). The TEETH take up little of these substances and none is found in tooth enamel. This slower metabolism of the tooth structure may be explain why the teeth of adults are slow to be affected by diet.

Excretion and Balance. Excess calcium and phosphorus that have been taken into the body proper but not built into tissues, plus some of these mineral elements discarded by tissues, are excreted through both the KIDNEYS and the INTESTINE, and the relative amounts that leave the body by one route or the other vary with numerous conditions. Hence, the only way to tell how much of these elements has been retained in the body is by analyses of the food intake, feces and urine. When the calcium or phosphorus intake (in food) equals the quantity lost through urine and feces, the body is said to be in calcium or phosphorus equilibrium or BALANCE. If loss exceeds intake, there is NEGATIVE BALANCE; when the quantity absorbed is in excess of that excreted, POSITIVE BALANCE, there must be RE-

TENTION of these mineral elements in the body. Obviously it is advantageous to have the body stores of these elements built up, rather than drained by losses, especially in growing children when new bone tissue is being formed and the bones are being strengthened by further deposits of calcium phosphate.

Requirements. How much calcium and phosphorus need to be supplied in the food daily? Experiments have shown that the average requirements for ADULTS are about 0.55 gram calcium and 0.88 gram phosphorus per day, *i. e.*, such amounts will just suffice to balance the loss of these elements from the body and provide for the "wear and tear" on tissues already built. Of course there are INDIVIDUAL VARIATIONS, according to weight, to how well these elements are absorbed from the food, etc. Although CHILDREN are of smaller size, they require several times as much of these mineral elements per unit of body weight as adults, because an extra "growth quota" should be provided for building new bone and other tissues.

Children should STORE calcium and phosphorus, especially the former. They will go on growing on diets that provide less than desirable quantities of these elements, but the bones and teeth will not be of as good quality, or growth may not be so rapid as with a more liberal calcium and phosphorus intake; if the quantity of either element is too limited, growth may be stunted. At levels of about 1 to 1.5 grams daily of each of these elements in the diet, children show "maximum retention," *i. e.*, as much calcium and phosphorus is provided as the body can store.

Some nutritionists believe that adults would also benefit by higher levels of mineral intake—enough not only to make up for daily losses of these elements but to build up reserve stores of calcium and phosphorus in the bones. Many think that the fragile bones, which are common in old people, are due to a life-long habit of taking too little of these elements in the diet.

Standard Allowances. By this term we mean the dietary standards that have been fixed by nutritionists as desirable. The diet should provide more minerals than just the MINIMUM that is required, in order to allow for the possibility of their incomplete utilization from the food and for the fact that extra amounts of them will often be of benefit to the body. Usually about 50 per cent more than the minimum requirement is allowed as a "margin of safety." The daily standard allowances for calcium, as set by the Food and Nutrition Board of the National Research Council in 1948, are as follows:

	Calcium gms.
Adults (avg.)	1.0
Pregnant women	1.5
Nursing mothers	2.0
Children:	
Infancy to 9 years	1.0
10–12 years	1.2
13–15 years, girls	1.3
13–15 years, boys	1.4
16–20 years, girls	1.0
16–20 years, boys	1.4

The high allowances for calcium in the diet during the later months of pregnancy and for women who are nursing an infant, are necessary to provide for the calcium needs of the growing fetus or to secrete calcium-rich milk without undue drain on the reserve stores of this element in the mother's own body.

Formerly 1.3 gm. of phosphorus was the recommended daily allowance for adults, 1.0 to 1.5 gm. for children. In its most recent recommendations, the Food and Nutrition Board states that the phosphorus allowance for adults should be about one and one half times that for calcium, while for children and women in the latter half of pregnancy phosphorus intake should at least equal the increased amounts of calcium recommended. However, they feel it is safe to assume that enough phosphorus will be provided if the calcium and protein needs are met by common foods (milk carries both calcium and phosphorus liberally, along with protein), so that it is no longer necessary under ordinary circumstances to calculate the phosphorus content of the diet.

Calcium and Phosphorus Content of Foods. While it might seem that a little more or less than a gram (about $\frac{1}{30}$ of an ounce) of each of these elements should be easily obtainable in a day's food, it must be remembered that the mineral content of foods is relatively low, since foods consist mostly of water, fiber and organic materials. The calcium or phosphorus content of foods may be seen from Table XIII to vary from mere traces to slightly less than 1 gram per 100 grams of food (1. per cent). In general, foods of LOW MOISTURE CONTENT (hard cheese, nuts, dried legumes, dried fruits) show HIGHER mineral values; fresh fruits and vegetables which contain much water have such low mineral content that a considerable bulk of them must be consumed if they are to be valuable sources of these elements.

Calcium is UNEVENLY DISTRIBUTED in foods, but is particularly ABUNDANT in DAIRY PRODUCTS and GREEN LEAFY VEGETABLES; **phosphorus** is

TABLE XIII. CALCIUM AND PHOSPHORUS CONTENT OF SOME TYPICAL FOODS*
(In grams per 100 grams of food, or on percentage basis)

	Calcium.	Phosphorus.
	gms.	gms.
Cheese:		
Hard (American)	.87	.61
Soft (cottage)	.08	.26
Milk	.12	.09
Eggs	.05	.21
Lean beef	.01	.20
Bread:		
Whole wheat	.06	.37
White (avg. coml.)	.05	.10
Nuts:		
Almonds	.25	.47
Walnuts	.08	.38
Legumes:		
Beans, dried	.15	.46
Beans, lima, fresh	.06	.16
Peanuts	.07	.39
Fruits:		
Dried apricots	.08	.12
Dried prunes	.05	.08
Fresh apples	.006	.010
Fresh peaches	.008	.022
Vegetables:		
Leafy:		
Turnip tops	.26	.05
Kale	.22	.06
Green:		
Broccoli	.13	.07
String beans	.06	.04
Root:		
Carrots	.04	.04
Turnips	.04	.03
Potatoes:		
Sweet	.03	.05
White	.01	.05
Fruit:		
Tomatoes	.01	.03
Summer squash	.015	.015

* Figures from Tables of Food Composition, U. S. Dept. Agriculture, Misc. Pub. No. 572, 1945.

chiefly associated with PROTEIN-RICH FOODS and CEREAL PRODUCTS. For detailed figures as to the calcium content of foods not listed in the table above, see tables of the Nutritive Values of Common Foods in the Appendix.

How to Get Standard Allowance of Calcium in the Diet. Only a few foods are relatively RICH IN CALCIUM; these include cheese and milk, most leafy vegetables, legumes and nuts, dried fruits, and green vegetables, especially broccoli. Most root vegetables, oranges, strawberries, and eggs also have a fair calcium content. Due to the addition of milk solids, enriched white bread now contains almost as much calcium as that made from whole wheat. Fresh fruits and vegetables, other than mentioned above, contribute lesser but appreciable amounts, when taken in liberal quantities.

PHOSPHORUS is not so difficult to get, since it is provided more liberally than calcium by many foods. It is richly supplied by lean meats and cereal products, which are poor sources of calcium. In spite of the fact that about half of the phosphorus content of cereal grains is in the form of insoluble, and hence unutilizable, compounds, a diet that supplies the standard allowances for protein, calcium, and vitamins will almost certainly be adequate in phosphorus.

It is difficult to plan a dietary which will meet optimum standards for calcium without any MILK. A pint of milk will contribute almost three-fourths of the daily calcium quota for the adult, and liberal servings of foods that carry lesser amounts of calcium would be required to replace it. About $2\frac{1}{3}$ ounces of American cheese are equivalent in calcium content to a pint of milk. The high calcium requirements of growing children are almost sure to be met if they receive a quart of milk daily.

On p. 183 are several COMBINATIONS OF COMMON FOODS which, in the quantities designated, would furnish 0.8 gm. calcium, the daily quota formerly set for ADULTS. The Food and Nutrition Board has just recommended (1948) that this allowance be raised to 1.0 gram. Foods which would provide the higher allowance of calcium (1.4 gm.) recommended for RAPIDLY GROWING BOYS from 13 to 20 years of age are also given, and the calcium allowance for PREGNANCY is very similar (1.5 gm.).

Relative Utilization of Calcium in Different Foods. Calcium in foods is AVAILABLE FOR USE in the body only to the extent to which it is absorbed from the intestine. In certain foods it is present in more readily absorbed forms than in others, while a few foods contain calcium in insoluble and hence unabsorbable condition. The calcium in milk is that best utilized by man and its availability is not altered in homogenized, pasteurized or otherwise heat-treated milk,[1] although a very small amount of calcium is rendered insoluble by heating (precipitate on bottom of pan in which milk is

[1] Steggerda, F. R., and Mitchell, H. H., J. Nutrition, v. 31, p. 4, 1946.

FOODS THAT FURNISH A DAY'S ALLOWANCE OF CALCIUM

For Adult (0.8 gm.)

	per cent of quota
Milk, 1 pint	73
Vegetables: 1 serving each of: green (not leafy), root, potato	14
Bread, whole wheat or enriched, 4 slices or 3 slices and 1 serving whole grain cereal	7
Egg, 1	3
Fruit, fresh, 2 servings	3
	100

	per cent of quota
Milk, ½ pint (full glass)	36.5
Vegetables: 1 serving each of: leafy (not spinach), root, potato	34
Bread, 4 slices plus 1 serving whole grain cereal	9
Beans, 1 cup navy, or ½ cup soybeans	11.5
Fruit, 1 serving dried or citrus fruit, 1 serving fresh fruit	9
	100.0

For Adult (0.8 gm.) Without Milk

	per cent of quota
Cheese, 2 ounces	30
Vegetables: 1 serving each of: leafy (not spinach), broccoli, sweet potato	46
Bread, 4 slices	7
Egg, 1	3
Peanut butter, 2 tbsp.	3
Meat, 3 oz. serving	2
Fruit: 1 serving dried fruit, 1 serving fresh fruit	9
	100

For Teen-age Boy (1.4 gm.)

	per cent of quota
Milk, 1 quart	82
Vegetables: 1 serving each of: green or yellow, root, potato; Bread, 4 slices; Egg, 1; Meat, 3 oz. serving; Fresh fruit, 1 serving; Orange juice, 8 oz.	18
	100

heated). Broccoli, cauliflower, and kale rank almost with milk in availability of their calcium,[2] while that in carrots, lettuce and string beans is utilized (by rats) 75–85 per cent as well as that in milk.[3] Rose and MacLeod[4] found that young women assimilated well the calcium fed in carrots or almonds, when these foods furnished half, or somewhat more than half, of the calcium of the diet and the remainder was provided in milk.

The green, leafy vegetables are perhaps the next most important source of calcium after milk, and hence it is of considerable interest to know to

[2] Fincke, M. L., J. Nutrition, v. 22, p. 477, 1941.

[3] Shields, Mitchell, *et al.*, J. Nutrition, v. 20, p. 263, 1940.

[4] Rose, M. S., J. Biol. Chem., v. 41, p. 349, 1920; Rose and MacLeod, J. Biol. Chem., v. 57, p. 305, 1923.

what extent the human body can absorb and assimilate the calcium they carry. Experiments with rats have shown that in spinach,[5] chard and beet greens calcium is present in insoluble combination with the oxalic acid which these leaves contain, and hence is totally unavailable to the body. Plants that are unrelated botanically to those mentioned above have no oxalic acid and hence carry calcium in forms available to the body. Leafy vegetables with fairly well-utilized calcium include kale, cabbage, collards, turnip greens, and probably mustard and dandelion greens.

Much to-do has been raised as to whether an oxalic acid-containing vegetable like spinach might not only be no good for its calcium content but might rob the body of available calcium by forming insoluble oxalic acid salts with calcium in other foods like milk. Macy and co-workers[6] added 100 gm. puréed spinach to the daily diet of ten children, a mixed diet which was already adequate in calcium content; the addition of spinach did not significantly alter the calcium retention of the children and the investigators emphasized the value of spinach for its contributions of iron and vitamins. Remington and Smith[7] found that spinach, fed in relatively enormous amounts to rats, had no bad effects on growth or bone formation. Kohman[8] concurred in the conclusion that the oxalates in spinach have no effect on bone growth, provided the diet contains adequate available calcium. So the fear that oxalate-containing leafy vegetables may rob the body of needed calcium from other foods does not seem justified, unless the customary diet of the individual were lacking in calcium and these foods were taken in large quantities.

But the trend of recent experiments seems to indicate that a larger proportion of the calcium in the diet may go unutilized than was formerly thought. There is a wide difference between individual humans and between man and lower animals in this respect. Rats utilize much more of the calcium in foods than human beings do. However, these facts only emphasize the necessity of providing calcium in the human dietary in amounts considerably in excess of the quantity actually needed for body maintenance.

Frequency and Effects of Dietary Deficiencies of Calcium and Phosphorus. The results of several dietary surveys show that the diet is more likely to be DEFICIENT IN CALCIUM than in any other mineral element. Studies of 150 freely chosen American dietaries, each covering the food of

[5] Fincke, M. L., and Sherman, H. C., J. Biol. Chem., v 110, p. 427, 1935.
[6] Bonner, Macy, *et al.*, J. Pediatrics, v. 12, p. 188, 1938.
[7] Remington and Smith, Science, v. 101, p. 272, 1945.
[8] Kohman, Science, v. 101, p. 610, 1945.

a group of people for a week or more, showed the following results as to calcium and phosphorus intakes:[9]

Per Man Per Day

	Minimum, gm.	Maximum, gm.	Average, gm.
Calcium	0.24	1.87	0.73
Phosphorus	0.60	2.79	1.58

It will be seen that, while the AVERAGE intakes of these two mineral elements seem little, if any, below those recommended, average figures do not mean much in view of the tremendous ranges in individual diets. When some persons were receiving as little as 0.24 gm. of calcium in a day's food (about $\frac{1}{4}$ of the recommended allowance), many must have been getting less than optimum quantities of this element. That it is easier to get phosphorus than calcium in the diet is also readily seen from the figures on phosphorus intake. Because the main reliance for calcium in the diet rests on a few foods, such as milk, cheese, eggs, and green vegetables, persons who do not use these foods liberally are very likely to get less than optimum amounts of this important element.

What are the EFFECTS of a calcium or phosphorus intake that is insufficient for body needs? Since these elements are needed for the growth and rigidity of **bone tissue,** the results of such deficiencies are most marked in infants and young animals. Babies are born with comparatively soft and pliable bones. The bones should not only grow in size but be increased in rigidity by deposition in them of larger amounts of calcium phosphate. When children or young animals receive an insufficient supply of either calcium or phosphorus, there is great danger either that the GROWTH OF BONES will be STUNTED (Fig. 17, p. 186) or that bones will remain SOFT AND PLIABLE because too little mineral salts are deposited in them. Such conditions prevail in the disease called **rickets,** which is all too common among infants and young children (Fig. 19, p. 187). Many carry the pitiful effects of this childhood disease in malformed bones throughout life. A narrow chest (Figs. 18 and 19), contracted pelvis, knock-knees or bow-legs (see Figs. 19 and 47) are typical after-effects of rickets. It is an entirely preventable disease, due in large part to faulty diet.

An abundant supply of calcium and phosphorus (along with other dietary factors) is also necessary for the formation of good **teeth.** As the teeth are largely formed during the latter part of fetal life or during infancy,

[9] Figures taken from a table on Mineral Elements in 150 American Dietaries, page 229, Sherman's CHEMISTRY OF FOOD AND NUTRITION, 7th ed., Macmillan, 1916.

many cases of MALFORMED TEETH AND JAWS, and of early TOOTH DECAY, are undoubtedly due to the fact that the mother's diet was lacking in these elements during pregnancy or that the child received an insufficient supply of them during its first years of life. The mother's teeth and bones may also suffer during pregnancy or lactation, if a lack of calcium in the diet compels the maternal organism to draw on its own bony structure for the calcium and phosphorus needed to supply the child.



Fig. 17. Two puppies of the same age. The larger one had an abundant supply of milk; the smaller one had little milk but plenty of other food. In addition, the larger had been allowed to run about exposed to sunshine while the smaller was kept in a kennel. (Courtesy of Shattuck Farms, Andover, Mass.)

In the **adult,** the bones represent a considerable reservoir of calcium and phosphorus, which can be drawn on to make up a temporary deficiency in the diet without materially affecting their strength and rigidity. But if this dietary deficiency is continued over long periods, the bones may be robbed of calcium and phosphorus to such an extent as to become brittle and fragile. Moreover, the general health may be affected by continual supply of less than optimum amounts of calcium. It has been shown that rats



Fig. 18. The same puppies shown in Fig. 17 four months later, during which time both had been well supplied with milk (and sunshine). The one at the right is the one which was formerly stunted. His narrow chest indicates inability to recover completely from effects of the earlier lack of material for bone-building. (Courtesy of Shattuck Farms, Andover, Mass.)



Fig. 19. Rachitic child—note bow-legs with enlargement of bones about joints, deformity of chest and enlargement of abdomen. (Morse, "Clinical Pediatrics.")

respond to more liberal intakes of calcium with increased vitality, longer life, and production of healthier offspring. It is possible that sufficient supplies of calcium and phosphorus in the diet of adult human beings, to build up reserve stores of these elements in the bones to higher levels, might yield similar health benefits.

IRON AND COPPER

Uses in the Body. The functions of these two mineral elements in the body are so intimately associated that it is customary to consider them together. About 60 per cent of all the iron in the body is in the **hemoglobin** in the red blood cells, 30 per cent is in various storage depots ($\frac{2}{3}$ of this in the liver, spleen, and bone marrow), and the remainder is in the muscle tissues and in enzymes in the cells of all tissues. The blood is thirty times richer in iron than the average of other parts of the body. Hemoglobin, the iron-containing pigment that gives color to red blood cells, possesses the ability to take up OXYGEN in loose chemical combination. By means of it, oxygen is taken up in the lungs by the blood and carried to the tissues, which require oxygen for their life processes. After giving up some of its oxygen to the tissues and taking on carbon dioxide, the blood is returned to the lungs, where it loses carbon dioxide and is re-oxygenated. Thus hemoglobin plays an essential rôle in the oxidative processes that sustain life, and the smaller amounts of iron that are found in various tissues, other than blood, doubtless are also associated with vital oxidation-reduction reactions.

Copper is not a constituent of hemoglobin, but it is in some way necessary to the nutritional processes by which this important pigment is formed. An animal must receive an adequate supply of both iron and copper, in order to maintain the normal level of hemoglobin in the blood; conversely, ANEMIA (a condition in which the blood contains too little hemoglobin) may develop on a diet that is deficient in copper, even though plenty of iron is available. The mechanism by which copper AIDS IN HEMOGLOBIN FORMATION is not yet clear, but it is thought that it may act as a catalyst.

Iron Metabolism and Balance. New red blood cells must be made continuously, since they are being continuously destroyed. The LIFE OF RED BLOOD CELLS has been estimated as from 40 TO 120 DAYS, probably varying with circumstances. Most of the iron from destroyed red cells is not excreted, but is USED OVER AGAIN to rebuild hemoglobin for new red blood cells. The BONE MARROW is probably chiefly responsible for the formation of new red blood cells. These cells consist only in part of hemo-

globin, and all of the substances needed for their construction must be available. Since hemoglobin is a complex protein, PROTEIN is necessary for its formation as well as IRON and COPPER.

Since iron is a precious element that is conserved by the body for reuse, there is only a trace of it in urine and normally very little is **excreted** into the intestine. Most of the iron in the feces is food iron that has failed of absorption. As with calcium and phosphorus, many factors influence the degree to which iron of the food intake is **absorbed** into the body. Favorable factors are proper acidity of the stomach secretions, enough bile for good digestion of fats, plenty of calcium and vitamins in the diet,[10] and the presence of iron in readily absorbable form; intestinal putrefaction militates against good absorption of iron by formation of insoluble iron compounds, and diarrhea or frequent bowel evacuations naturally mean less complete absorption. There has been some evidence to show that more iron is absorbed where the need for this element is great,[11] but intestinal hygiene and liberal intake of vitamins (especially B-complex vitamins) certainly play an important rôle in securing good absorption under normal conditions.

Iron **balance**, *i. e.*, equality of intake and outgo, has been attained in adults on small amounts of iron in the daily diet, once the body has become adjusted to a low-iron diet. Adults have been maintained in iron equilibrium on intakes ranging from 4 to 7 mg. per day, or even less[12]; this is not surprising when we consider how the body conserves its iron stores for reuse and actually loses very little of this element daily. Hence, we know that the actual REQUIREMENT for iron, especially for full-grown men, is less than formerly thought, in fact is very small. But women and growing children have higher iron needs and it is desirable that the intake of iron be sufficient to allow for possible poor absorption and to keep up good iron reserves in the body.

When the diet supplies iron and copper in excess of body needs, these elements can be STORED IN THE LIVER (and to a lesser extent elsewhere) to be used later in time of need. The newborn infant comes into the world with a store of iron in its liver sufficient to last through the nursing period, since milk is a food that provides little iron. As the infant's extra store of

[10] Anderson, McDonough, and Elvehjem, "Relation of Dietary Calcium, Phosphorus Ratio to Iron Assimilation," J. Lab. & Clin. Med., v. 25, p. 464, 1940.

Fuhr, I., and Steenbock, H., "Effect of Dietary Calcium, Phosphorus and Vitamin D on the Utilization of Iron," J. Biol. Chem., v. 147, p. 59, 1943.

[11] Hahn, Whipple, *et al.*, J. Exp. Med., v. 69, p. 739, 1939; *idem*, v. 78, p. 169, 1943.

[12] Farrer and Goldhamer, J. Nutrition, v. 10, p. 241, 1935; Leverton, J. Nutrition, v. 21, p. 617, 1941; Leverton and Marsh, J. Nutrition, v. 23, p. 229, 1942.

iron is dependent to some extent upon the diet of the mother during pregnancy, the diet of pregnant women should be especially rich in iron.

Standard Allowances. The amount of iron required is influenced somewhat by SIZE and AGE, and to a lesser extent by SEX since women lose some iron through menstruation. Small children need less TOTAL iron than adults, but MORE PER UNIT OF WEIGHT (in order to build hemoglobin for their increasing volume of blood); the iron requirement of rapidly growing (adolescent) boys and girls is high. Women should be supplied with at least as much iron as men, in spite of smaller size. The DAILY ALLOWANCES for **iron** recommended by the Food and Nutrition Board, National Research Council, in 1948, are given in the table on this page. These provide for at least a 50 per cent surplus over actual needs and are considered liberal, especially those for normal adults.

STANDARD ALLOWANCES FOR IRON

	mg. daily
Adults	12
Pregnant women	15
Children:	
Up to 3 years	6–7
4 to 6 "	8
7 to 9 "	10
10 to 12 "	12
13 to 20 "	15

The requirement for **copper** is approximately $\frac{1}{10}$th that for iron (1–2 mg. daily). It is difficult to give definite figures for the copper requirement, nor is it necessary to do so, for copper is sufficiently widely distributed in foods so that the normal human dietary supplies enough of this element to meet body needs.

Iron Content of Foods. Figures for the amount of iron in some typical foods are given in Table XIV and iron values of other foods may be found in the Appendix. Since we measure iron in milligrams ($\frac{1}{1000}$ths of a gram), it will be evident that the quantity of iron in foods is much less than that of calcium and phosphorus, ranging from only 0.07 milligram in whole milk to 12 milligrams in liver, per 100 grams or $3\frac{1}{2}$ ounces edible portion of the food. In many instances the distribution of iron parallels that of other minerals, as it is relatively high in foods of low moisture content—DRIED FRUITS and LEGUMES, NUTS, and WHOLE GRAIN CEREALS—and also in green, LEAFY VEGETABLES. But milk, which is one of the best sources of calcium, is poor in iron, while organ meats like LIVER are unusually rich in this element. EGG YOLK is another rich source of iron and lean meats contribute considerable quantities of it.

TABLE XIV. IRON CONTENT OF SOME TYPICAL FOODS

Food.	Iron per 100 gm. E. P.[13]	Food.	Iron per 100 gm. E. P.[13]
	mg.		*mg.*
Liver	12.1	Breakfast cereals, uncooked:	
Beef:		Oatmeal	5.2
Raw, lean	2.8	Whole wheat	3.8
Raw, medium fat	2.4	Farina	.8
Egg yolk	7.2	Farina, enriched	1.3
Eggs, whole	2.7	Bread, whole wheat	2.6
Molasses, cane	6.7	Bread, white, enriched	1.8
Nuts:		Bread, white, not enriched	.8
Almonds	4.4	Vegetables:	
Peanuts or peanut butter	1.9	Leafy:	
Pecans	2.4	Chard	4.0
Walnuts	2.1	Beet greens	3.2
Legumes:		Spinach	3.0
Beans, dried, uncooked	10.3	Turnip greens	2.4
Beans, dried, baked	3.4	Kale	2.2
Beans, fresh, lima	2.3	Green:	
Peas, fresh	1.9	Broccoli or Brussel sprouts	1.3
Soybeans, fresh	2.8	String beans	1.1
Fruits, dried:		Root:	
Apricots	4.9	Beets	1.0
Peaches	6.9	Carrots	.8
Prunes	3.9	Turnips	.5
Raisins	3.3	Potatoes, white or sweet	.9
		Fruit:	
		Tomatoes	.6
		Summer squash	.4
		Fruits, fresh:	
		Apples	.3
		Oranges	.4
		Peaches, or bananas	.6
		Milk	.07

However, the total amount of iron in a food does not tell the whole story as to how much of it is AVAILABLE FOR USE BY THE BODY. Some of the iron may be held in organic combinations which render it unabsorbable and so useless for HEMOGLOBIN FORMATION (the body's main use for iron). Figures as to the availability of iron for hemoglobin formation have been determined by chemical methods and feeding experiments on anemic animals. It is open to question whether these figures would apply to normal

[13] Figures from Tables of Food Composition, U. S. Dept. Agriculture, Misc. Pub. No. 572, 1945.

human beings on ordinary mixed diets. However, they do indicate that probably the iron in muscle meats, leafy and root vegetables is less well utilized than that in organ meats, egg yolk, whole grains and dried fruits. The small amount of iron in milk is very efficiently utilized. When consumed in large quantities, even foods of relatively low iron content, such as milk, and fresh fruits and some vegetables, may supply considerable iron.

Since we know that the standard allowances of iron provide a liberal "factor of safety" and that numerous other factors in foods may influence the assimilation of iron in the diet as a whole, less stress is laid now than formerly on the special type of iron carried by a given food and more stress upon the adequacy of the diet in ALL nutritive essentials. If the total iron content of the food is sufficient to meet the iron allowance for the normal individual and if the diet as a whole is such as to promote good utilization of iron, there is little need to worry about the special form in which it is provided.

How to Get Standard Allowance of Iron in the Diet. The quantities of some common foods that would furnish the daily iron allowance for a normal adult, and for a child or pregnant woman, are given in Table XV. Many other combinations are, of course, possible.

TABLE XV. FOODS THAT FURNISH DAILY IRON ALLOWANCE

For **Adult** (12 mg.)		For 13-year-old **Child** or **Pregnant Woman** (15 mg.)	
	Iron *mg.*		Iron *mg.*
Meat, med. lean, 3 oz., cooked	3.5	Liver, 3½ oz., cooked	6.7
Egg, 1	1.4	Egg, 1	1.4
Beet greens, ½ c., cooked	3.2	Prunes, 4–5 medium	1.9
Apricots, dried, 4–6 halves	1.5	String beans, ½ c., cooked	1.1
Orange, 1 small	.4	Oatmeal, ⅔ c., cooked	1.6
Bread, whole wheat, 3 slices	1.8	Bread, enriched, 4 slices	1.8
Milk, 1 pint	.3	Milk, 1 quart	.7
	12.1		15.2

Adequacy of American Diet as to Iron. Failure of the iron content of the ordinary diet to be adequate for body needs is considered to occur infrequently now, provided most foods are taken in their natural state and not highly refined. Several factors contribute to a greater feeling of confidence as to adequacy of dietary iron under ordinary conditions. First, the

actual daily need for new supplies of iron has been shown to be smaller than previously thought, especially in normal adults. Then Americans are probably eating more green vegetables than formerly, while the addition of iron to enriched white bread and cereals has added iron to staple foods formerly poor in it. A diet that supplies plenty of calories, protein, calcium and vitamins will seldom be inadequate in its iron content even though really iron-rich foods are taken in small quantities. For instance, if one follows recommendations to include in the daily diet 1 pint of milk, 1 serving meat, 1 egg, 3 or 4 slices of whole wheat or enriched bread, 3 servings of vegetables (using colored and leafy ones fairly often) and 2 servings of fruit, these foods alone will provide 9 to 12 mg. of iron daily.

Hence, when we find people who show symptoms of having too little iron for body needs, we are apt to attribute this to poor utilization of iron in the food and to try to remedy causes of this condition. Insufficiency of iron intake to meet body needs occurs chiefly where body needs for iron are unusually large—among young children, adolescent boys and girls, pregnant women and those whose menstrual loss of blood is large, and in any condition that involves considerable losses of blood (blood donors, diseased conditions where small hemorrhages occur over a long period, etc.). Young children, and others whose iron needs are high, should have the ordinary diet supplemented with such iron-rich foods as liver, egg yolk, leafy vegetables and dried fruits (sieved, if necessary).

IRON DEFICIENCIES in the body may arise in any of three ways: (1) due to an iron-poor diet which has been taken over a long period, (2) due to conditions which make for unusually poor utilization of the iron supplied in the food, or (3) due to unusual needs for iron in the body. While the last two causes are more often responsible for iron deficiency than an insufficient supply of iron in the diet, they belong in the realm of medicine rather than that of nutrition. Anemias that occur in diseased conditions where DIARRHEA is a prominent symptom are due chiefly to poor utilization of the iron that is taken. Anemias that result from recurrent HEMORRHAGES or EXCESSIVE DESTRUCTION OF RED BLOOD CELLS (primary or pernicious anemia) are associated with a greatly increased need for iron for blood replacement. Most of these anemias cannot be prevented or treated by diet alone. Differentiation between the different types of anemia and their treatment should be left to the physician. Occasionally cases of true "NUTRITIONAL ANEMIA" occur, which are due primarily to the fact that the diet has furnished too little iron to meet body needs, and such iron deficiencies could certainly have been prevented and may often be cured by iron-rich diet.

In **nutritional anemia,** due to the insufficient supply of iron, either fewer red cells are built or the red cells contain less than the normal amount of hemoglobin. In either case, the oxygen-carrying capacity of the blood is lowered, though quickened heart beat and respiration may partly compensate for the diminished oxygen content of the blood by sending it around more rapidly. Symptoms of PALENESS, WEAKNESS, shortness of breath, lack of appetite, and SLOWING UP OF VITAL FUNCTIONS of the body are associated with LOWERED HEMOGLOBIN CONTENT AND OXYGEN-CARRYING ABILITY OF THE BLOOD. Since iron is not the only substance needed to build hemoglobin and still other substances are required for the "stroma" (framework of the cell) of red cells, the diet in nutritional anemia should provide not only **iron** but also PROTEIN, COPPER, possibly other minerals, and VITAMINS in liberal quantities. In other words, it should be a well-balanced diet, not only rich in iron but adequate for ALL body needs.

IODINE

Function in Body. Iodine constitutes only about three parts per million of the body weight. Nevertheless, it is extremely important to the normal metabolism. About $\frac{3}{5}$ of all the iodine in the body is concentrated in the thyroid gland, which secretes into the blood a hormone, THYROXIN, that contains considerable amounts of iodine. Thyroxin is an iodine-containing derivative of the amino acid, tyrosine; some of it exists free in the blood and some is bound in a complex protein, called thyroglobulin. The free substance, when circulated through the body, has the effect of stimulating the RATE OF OXIDATION in body tissues. The secretion of this potent hormone is regulated so that too much of it will not be released at any one time under normal conditions. Also stores of iodine are maintained in the thyroid and other tissues, so that the body will not be dependent upon its day-to-day supply of this element.

If the food and water supplies too little iodine over long periods, the stores of this element become depleted (since the thyroid goes on manufacturing thyroxin). In time, the thyroid responds to the shortage of iodine by making less thyroxin than normally and the "fires of metabolism" in all body tissues burn more slowly. Since less foodstuffs are oxidized, there is a tendency to increased weight, lowered vitality, sluggish mentality, and the whole organism suffers. The thyroid, which is working under difficulty when insufficiently supplied with iodine, becomes enlarged, a condition known as **simple goiter.** Hence, it will be evident that the required amounts of iodine must be furnished to the body if its welfare is to be maintained.

Amount Required and How to Get It. The quantity of iodine used in the body is too small to permit of stating the daily requirement with accuracy. Estimates place the adult daily BASAL requirement for iodine as about $\frac{1}{1000}$th of a milligram per kilogram of body weight or 0.07 mg. for a 70 kg. man. However, an OPTIMUM ALLOWANCE, which takes into account individual activity and a factor of safety, is placed at between 0.15 and 0.30 mg. per man per day.[11] Thus we need only approximately $\frac{1}{1000}$th as much iodine as iron. Doubtless individuals differ somewhat in iodine requirement; at any rate we know that (as with other minerals) the need for iodine is somewhat greater in adolescence and pregnancy.

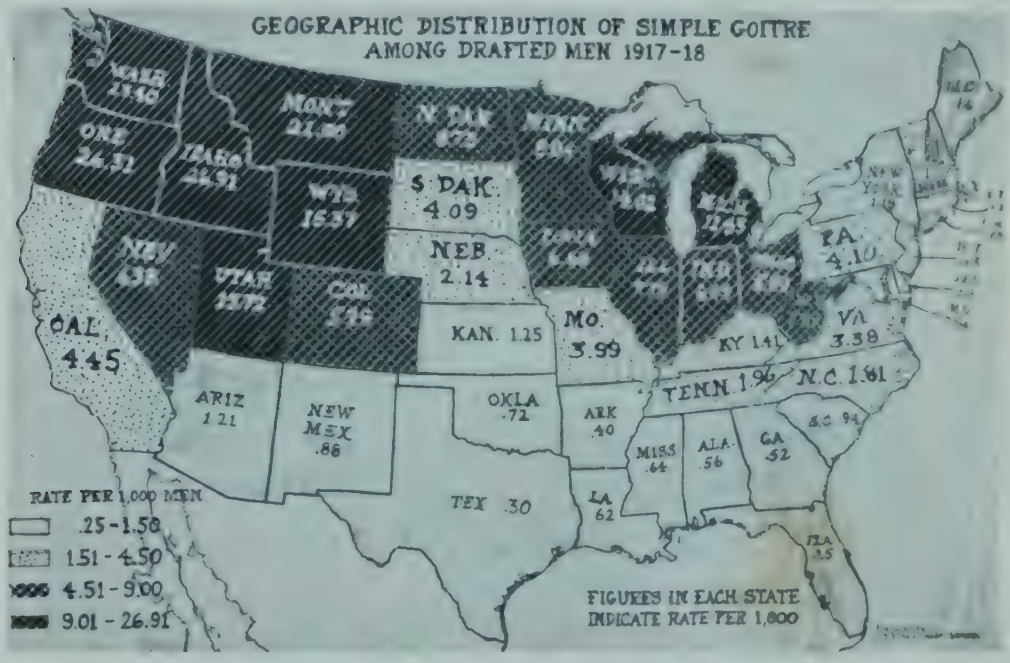


Fig. 20. So-called goiter map of the United States showing (in black) the regions where goiter is most prevalent. (Love and Davenport, "Defects Found in Drafted Men." Courtesy of U. S. Department of Public Health)

Most persons do not need to give thought as to how to get enough of this element, since the amounts required are so small and it is found, in minute traces at least, in most drinking waters and foods. The IODINE CONTENT OF WATER varies widely in different regions; it is highest near the sea and in regions where iodine-containing rocks are found. SEA SALT and SEA FOODS are among the richest sources of iodine, since small quantities of iodine salts are dissolved in the ocean. Foods grown on IODINE-POOR

[11] Scheffer, L., Biochem. Ztschr., v. 259, p. 11, 1933; Cole, V. V. and Curtis, G. M., J. Nutrition, v. 10, p. 493, 1935; and recommendations of Food and Nutrition Board, National Research Council, 1948.

SOIL contain considerably less of this element than do those grown in regions where the soil has a higher content of iodine salts.

Although much work has been done on the iodine content of foods, the amounts present are so minute and vary so greatly in different regions that



Fig. 21. Dead and hairless pigs produced by a sow on a diet which results in low iodine assimilation. Note the thick necks, indicating a goiterous condition. (From Hart and Steenbock, Hairless Pig Malady I.)

it is undesirable to quote definite figures. The iodine content of foods ranges from 1–10 parts PER BILLION in wheat to 500–5000 parts per billion in fish and shellfish from the sea (with even more in cod liver oil). The amount of this element in milk and eggs is dependent upon that present in

the feed of the producing animal; milk with high iodine content has been produced by mixing iodides in the cow's feed. In general, analyses indicate that milk, butter and vegetables, which are produced in regions where soil is at least of moderate iodine content, are fairly good sources of iodine; grains, legumes and fresh fruit are of lower iodine content; salt water fish, shellfish and cod liver oil are relatively rich in this element.

Occurrence and Prevention of Iodine Deficiency. For many years it has been recognized that **simple goiter**, now known to be in origin an iodine-deficiency disease, was especially prevalent in certain regions. For the most part, these regions were remote from, or cut off by mountain ranges from, the sea—mountain valleys in Switzerland, France, or Asia.



Fig. 22. The same sow which produced the pigs shown in Fig. 21 with a litter of normal pigs produced on the same ration fortified with 10 grams of potassium iodide per 100 pounds of feed. (From Hart and Steenbock, Hairless Pig Malady I.)

This disease has been found to occur more frequently in such interior sections of the United States as the basin of the Great Lakes, and in the Pacific Northwest, than in other parts of the country. In such regions, the iodine content of the water, soil, and locally grown foods is very low. Men are less subject to goiter than women, and the thyroid trouble is most likely to make its appearance at adolescence or during pregnancy. Babies and the young of domestic animals may be still-born and goiterous, even though the mother has not shown evidence of iodine insufficiency. Those in whom the iodine deficiency has not reached so great a degree may show other symptoms (low basal metabolism, sluggishness, etc.) less marked than thyroid enlargement. Occasional cases of simple goiter or less severe symptoms of iodine deficiency may occur in any region, but are compara-

tively rare in the southern portion of the United States and in coastal regions (see goiter map of the United States, Fig. 20, p. 195).

Simple goiter can be PREVENTED by an adequate supply of iodine. In goiterous regions the natural low iodine content of foods and water should be supplemented with iodine from other sources. Formerly impure salt from the ocean, which contains salts of iodine, was in general use; in recent years, highly refined salt (pure sodium chloride) has replaced natural sea salt for seasoning foods. Public health authorities now recommend that "IODIZED SALT" (salt to which sodium or potassium iodide has been added to a maximum of 0.02 per cent and minimum of $\frac{1}{10}$ that amount) should be used as a preventive against simple goiter, especially in districts where this disease is of common occurrence. Other preventive measures against iodine deficiency include (1) the addition of small amounts of soluble iodine salts to city water supplies (at certain seasons and under direction of public health officers), (2) giving iodine compounds in tablet form to school children, and (3) the more liberal use in goiterous regions of sea foods and vegetables shipped in from non-goiterous sections (foods of higher iodine content than those of the region). The experiments of Marine and Kimball[15] (in Akron, Ohio) showed that 99 per cent of the simple goiter prevalent among adolescent school children of that region could be prevented by the administration (twice weekly for a month, repeated twice yearly) of small doses of sodium iodide dissolved in drinking water. Iodized salt seems the simplest and most widely distributed preventive agent against goiter.

The PREVENTION of SIMPLE goiter belongs in the field of nutrition, since it involves replacement of an essential nutrient which should normally be supplied in food. It should be borne in mind, however, that there are several types of goiter which call for radically different treatment. Once goiter has developed, its diagnosis and treatment should be entrusted only to a physician.

RULES FOR INSURING SUFFICIENT MINERAL ELEMENTS IN THE DIET

1. Adults should take at least a pint of milk per day in some form; children up to at least fifteen years of age (and better up to 20 years) should have a quart of milk daily.
2. Use fruits and vegetables liberally, especially dried fruits and leafy vegetables.
3. Use eggs or cheese frequently, and moderate amounts of meat, daily if possible. Occasional use of liver or kidney is also helpful.
4. If in a goiterous region, use iodized salt, or be sure to include frequently in the diet sea foods and vegetables from non-goiterous regions.
5. If the amount of fruits and vegetables, eggs and meat in the diet must be some-

[15] Marine and Kimball, J.A.M.A., v. 77, p. 1068, 1921.

what limited because of their expense, AT LEAST half of the bread and cereals for adults should be of the whole grain or "enriched" type, instead of those made from highly milled grains. The unmilled cereals are best for children, as they help to insure a surplus of mineral salts during the growth period.

QUESTIONS AND PROBLEMS

1. For each of the following mineral elements, tell in what special tissue of the body most of it is found and what function it fulfills in this tissue: calcium, phosphorus, iron, and iodine. What function does copper have in the body? In what other tissues are these mineral elements found and give any special uses for them, other than those named above?

2. Give the minimum requirement and standard allowance of normal adults for calcium, for phosphorus, and for iron. Explain why the latter is higher than the former. Explain why growing children need more of these mineral elements PER UNIT OF BODY WEIGHT than adults. Are their TOTAL needs necessarily larger than those of adults, and why? Why are the allowances for pregnant women and nursing mothers higher than those for other adults?

3. Can the body build up reserve stores of mineral elements, provided the diet supplies more than enough to meet current body needs? Where are calcium and phosphorus stored? Where is iodine stored? Iron and copper? Why are reserve stores of these minerals of advantage to the body?

4. By what route or routes are the calcium and phosphorus that are not retained in the body excreted? What is meant by calcium or phosphorus balance, and how are they determined? What condition is indicated by a negative balance, a positive balance? Through what channel is iron excreted? Explain why by far the largest part of the iron in the feces is food iron that has failed of being absorbed.

5. When milk has been taken into the alimentary tract, which of the following of its ingredients will probably be absorbed into the body proper most rapidly and completely, and which most slowly and incompletely—milk sugar, proteins, fat, or calcium? Compare the average extent to which calcium is utilized with the degree of utilization of the fuel foodstuffs in foods. Why is the absorption of mineral elements less complete? Name three factors that have a favorable influence and three that have an unfavorable influence upon the absorption of mineral elements.

6. What is the richest food source of calcium, of iron, of iodine? Name five other foods comparatively rich in calcium, five rich in phosphorus, five rich in iron, and three rich in iodine.

7. Following the rules on p. 198 for insuring sufficient mineral elements in the diet, plan a day's meals that will be at least fairly rich in minerals.

Consult the tables of Nutritive Values of Foods in the Appendix and calculate the approximate amounts of calcium and iron furnished by your planned dietary. Compare the amounts furnished with the standard allowances of these elements for adults.

8. What are the symptoms of nutritional anemia and under what conditions may it be caused? Does the existence of nutritional anemia necessarily mean that the diet furnished too little iron? Explain reasons for your answer. What kind of diet will help to prevent or cure nutritional anemia? Simple goiter is a deficiency disease caused by lack of what element? In what regions is it most prevalent, and why? At what periods of life is it most apt to develop, and why? Describe two public health measures that have been used successfully in preventing simple goiter.

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CHAPTER 13

GENERAL INFORMATION ABOUT VITAMINS

DISCOVERY. The most dramatic chapter of nutrition deals with the discovery and study of the group of **body regulators** called **vitamins.** Up to the early part of this century, it was generally considered that only fuel foodstuffs, protein and mineral elements were needed for normal nutrition, in which event the proper amounts of purified proteins, carbohydrates, fats and mineral salts should suffice to supply all needs of the body. Most investigators had paid little attention to the experiments of Lunin in the 1880's, when he found, disconcertingly, that mice died if fed on an artificial mixture of all the then known constituents of milk. Lunin concluded, "A natural food, such as milk, must therefore contain besides these known principal ingredients small quantities of unknown substances essential to life."

About 1906 to 1912, Hopkins in England established by careful experiments that rats sickened and died on diets of pure protein, fat and carbohydrates, to which all the presumably necessary mineral matter had been added. Less than one third of a teaspoonful of milk, added to the highly purified diet, made all the difference between life and death for the experimental animals. An alcoholic extract of dried milk or of certain vegetables also enabled the animals on purified diets to live and grow, but the ASH of milk or vegetables was ineffectual. Thus Hopkins showed that the essential "unknowns" that exist in foods in the natural state are ORGANIC (rather than inorganic) substances that can be dissolved in alcohol. For his work in establishing the existence of the substances we now call vitamins, Hopkins later received a Nobel prize award.

Meantime (1908–1911) Osborne and Mendel in America were following up the same kind of animal experimentation with diets composed of chemically pure foodstuffs, which fulfilled all the hitherto recognized requirements for good nutrition. Their rats could be kept alive and growing by including in their diet small amounts of "protein-free milk," a powder made by removing both fat and protein from milk and evaporating the resulting whey. Again the ash of the whey showed no protecting powers. These investigators, and McCollum and Davis of Wisconsin, showed in-

dependently (1913) that fatty foods, such as butter and egg yolk, contain traces of another type of substances also required for normal nutrition. So it was proved that, not only are these nutritive essentials organic in nature, but that some of them are soluble in water while others are insoluble in water but are soluble in fat solvents. It became evident that there must be two or more of these mysterious but potent substances carried by natural foods.

These essential "trace" nutrients were called by some "FOOD HORMONES." McCollum proposed the terms "fat-soluble A" and "water-soluble B" to designate the "ACCESSORY FOOD SUBSTANCES" found in butterfat and milk whey, respectively. In 1912 Funk, having obtained from rice bran a concentrated preparation of one of these potent substances that seemed to belong to the class of chemical compounds called amines, proposed that collectively they should be known as "VITAMINES" (amines essential to life). This name caught the popular fancy and has persisted, in spite of the fact that only one of these substances (the one which suggested the name to Funk) has turned out to be an amine. At the suggestion of chemists, the final E has been dropped.

Definition. Vitamins may be defined as organic compounds, different from any of the previously described food materials, which are needed only in small amounts but are **necessary for normal growth and the maintenance of health.** All living organisms need vitamins, but not every vitamin that has been discovered is needed by all animals. Plants can manufacture most of the vitamins that they require, but animals must have most of their vitamins supplied in food. There are differences between the vitamin requirements of human beings and the lower animals.

The action of vitamins is not unlike that of "trace" minerals such as iodine and copper, in that the presence or absence of very small amounts of them in the food means the difference between normal and abnormal functioning of the body. The potent effects of very small quantities in regulating body processes also remind us somewhat of the action of the hormones (thyroxin, adrenalin, etc.) that are formed by various ductless glands. Vitamins differ from the mineral elements in that they are ORGANIC substances (some of them complex compounds), while they differ from hormones in that (at least for the most part) they are not formed within the body but MUST BE SUPPLIED IN FOOD.

It is easier to describe the effects of vitamins, or lack of them in the food, than to define them as a group. This is because they have turned out to be a heterogeneous group of substances which differ widely in their chemical nature and in their physiological action. Also a few vitamins, required to

be furnished in the food of man, can be formed by some animals in their own bodies. Thus men get scurvy on diets that provide no vitamin C in fresh fruit or vegetables, but rats make this vitamin in their bodies and do not need it in food.

Distribution in Foods. The existence of vitamins was overlooked for many years because the foods consumed by man usually provided enough of them to prevent disastrous results to health. Most foods, as supplied by nature, contain some of several vitamins, and the foods in an ordinary mixed diet supplement each other in vitamin content. The quantities of these substances present in foods was too small to have been detected by chemists, and fortunately only small amounts of them are required to avert nutritional disaster. In occasional instances, when the choice of foods was limited for one reason or another, diseased conditions did arise (*e. g.*, scurvy occurred on long sea voyages, in besieged cities, or in times of famine), but it was many years before it dawned upon people that such mysterious diseases might be caused by the LACK of something in the diet. Since refined foods, such as highly milled grains, have assumed a more prominent place in the diet, ill health due to vitamin deficiencies has become more frequent.

What foods are our chief sources of vitamins? Animals get most of their vitamins either directly from plants, in which they are formed by the action of sunlight, or indirectly from animals which have fed on plants. The green leaves of the plant are its chemical laboratories, in which vitamins are made along with many other substances. Hence, green leafy vegetables have high content of most vitamins, as have also the green, growing shoots of plants; seeds, such as legumes, nuts and whole grain cereals, also have a good content of certain vitamins; root vegetables and fruits and vegetables of high water content usually contain smaller amounts of most vitamins, although there are notable exceptions in the case of certain vitamins or of special fruits and vegetables. It should be remembered that the different vitamins are often unevenly distributed in foods, while the vitamin content of fruits and vegetables may vary considerably, depending upon the soil on which they are grown, stage of ripeness when picked, conditions of storage, and other factors.

The lean flesh of animals (muscle meats) provide certain vitamins, but organs, such as liver and kidneys, are much richer in vitamin content. Certain animals are useful to man in that they concentrate vitamins in foods suitable for human consumption. Thus cows and hens put vitamins from their food into MILK and the YOLKS OF EGGS, which are valuable sources of vitamins. The vitamin content of eggs and milk will vary according to the

relative amount of vitamins in the animals' feed (*e. g.*, cows on green pasturage in summer give milk of higher vitamin content than do those fed only dried hay and grain in winter). Fish store certain vitamins in their body fat, and especially in their livers, which accounts for the fact that FISH LIVER OILS are our richest source of these particular vitamins.

Naturally, the fat-soluble vitamins are found chiefly in fatty foods—liver, butter, egg yolk, etc. Water-soluble vitamins are more abundant in fruits and vegetables, whole grains and legumes, lean meats. Milk carries both water-soluble and fat-soluble vitamins, the latter in the fat globules. While such facts about the general distribution of vitamins in foods are interesting and useful, there are many exceptions in regard to individual vitamins, so that each vitamin must be studied separately to determine what foods are needed to furnish it in amounts adequate for health.

Number and Naming of Vitamins. Attracted by the mysterious but potent rôle of these newly discovered substances, nutritionists continued to investigate vitamins with unflagging zeal. It soon became apparent that "fat-soluble A" and "water-soluble B" both comprised not one but a GROUP of vitamins, each of which had a separate, indispensable rôle in nutrition and different properties. Almost the only property which the members of each group had in common was their solubility, either in water or in fats and fat solvents. The water-soluble group proved especially complex and years of patient research have probably not yet discovered all of its factors. About fifteen different vitamins have thus far been recognized and their chemical identity established, while perhaps as many more have been said to exist and to be necessary for health of certain animals. A number of the recognized vitamins have not been proved to be essential for man. Those that have been shown to be essential in human food in fairly considerable amounts will be taken up individually in the three following chapters.

The naming of vitamins at first presented a problem, since little was known as to their chemistry. In fact, an early suggestion was that the two groups (water-soluble and fat-soluble) should be called "factor X" and "factor Y." As the groups became separated into several factors, the different vitamins were designated by the LETTERS of the alphabet, either in order of their discovery or by the initial letter of some word suggestive of their rôle in nutrition, *e. g.*, vitamin K from the Danish word for coagulation (of blood). The fraction originally known as vitamin B became subdivided into many different chemical substances, which were called B_1, B_2, etc., or by their chemical names. As the chemical identity of the different vitamins was established, CHEMICAL NAMES gradually supplanted the

earlier designation by letters and, of course, they are to be preferred as more definite and descriptive than letter symbols, at least from the chemist's viewpoint. However, the letter system is still in common use and offers a convenient "shorthand" way of referring to individual vitamins. In the following chapters, we shall use both letters and chemical names, usually stated together, in order to familiarize the student gradually with the chemical nomenclature of the vitamins.

Isolation and Synthesis of Vitamins. These technical terms are used to describe the long and difficult labors of the chemists, which were necessary in order to find out what the vitamin "unknowns" consisted of chemically, and how to make them in the laboratory. At first this seemed an impossible task, since vitamins were present in foods in such minute traces. The dry weight of a man's food intake for a day is from one to one and a half pounds, while the total vitamins in his food, if separated, would appear as only a few crystals—about one part per five thousand parts of dry food and of course much less in the moist foods as eaten.

To add to the difficulty, vitamins are organic substances and hence liable to destruction by heat, oxidation, and chemical processes used in their extraction. But the magnitude of the task and the interesting rôle of vitamins in nutrition constituted a challenge to chemists, who continued their painstaking labors sometimes for twenty-five or thirty years before the goal was attained. Scientists in all parts of the world participated in the effort to transform vitamins from unknown mysterious substances, found only in traces in foods, into known, PURE CHEMICAL COMPOUNDS that could be made at will.

The first step was to obtain concentrated preparations of vitamins from materials where they occurred in nature in largest amounts. Vitamins A and D were extracted from fish liver oils, vitamins B_1 and B_2 from rice polishings, wheat germ and dried yeasts; vitamin C was first obtained in concentrated form from citrus fruits and red peppers. These crude extracts were further concentrated and purified until small quantities of apparently pure substances (usually crystals) were obtained, which were tested for vitamin activity and analyzed chemically. The final steps in determining the chemical groupings in the molecule of the pure substance, and finding out how to put these groups together to make the substance in the laboratory, were probably the most difficult part of the task.

Most of the longest-known vitamins (those needed by man in sizable amounts) are now obtainable, either in CONCENTRATED PREPARATIONS or as PURE, SYNTHETIC SUBSTANCES, at drugstores for a moderate cost.

Measurement. When vitamins were made available as pure substances, a great impetus was given to their more exact measurement. In earlier years the quantity of a given vitamin in foods was assayed approximately in "BIOLOGICAL UNITS," the amount required to produce a certain nutritional response in some animal—either to give a standard rate of growth, to protect from or to cure the deficiency disease caused by lack of that vitamin. But animals of the same species, even from the same laboratory stock and with standardized conditions, varied somewhat in their biological response to vitamins, so that such units were at best an approximate measure.

As the various vitamins became known as pure substances, so-called "INTERNATIONAL UNITS" were established, based on a definite weight of the actual substance—*e. g.*, one International unit of vitamin C is .05 milligram of pure ascorbic acid. Although animals are still used to assay vitamins in foods or drugs, more accurate results are obtained because they are always compared with the effect of known quantities of the pure substance on control animals. Amounts of vitamins A and D in foods, and in pharmaceutical vitamin preparations, are usually stated in terms of International units.

The equivalent of a unit of each of these vitamins in terms of the pure vitamin (or provitamin) is as follows:

1 International unit of vitamin A = 0.0006 mg. β carotene
1 " " " " D = 0.000025 mg. calciferol.

With other vitamins, however, the quantity required and amounts present in foods can be stated directly in terms of WEIGHT units, milligrams or micrograms (1 1000 or 1 1,000,000 of a gram, respectively), and this method of expressing their measure is preferred as the most accurate.

Minimum Requirements and Optimum Allowances. Although the fact that we measure vitamins in such small units as milligrams or micrograms makes it apparent that they exist in foods in "trace" quantities, still the total amounts of them needed by the body are somewhat comparable to the amounts of certain minerals required. By actual weight, the **minimum daily requirements** of normal adults for the different vitamins range from less than .01 milligram of vitamin D to at least 25 milligrams of vitamin C. A man probably needs less vitamin D than copper (or other "trace minerals") per day, but his intake of niacin (one of the B-complex vitamins) should be of approximately the same magnitude as his iron intake, while the recommended allowance of vitamin C for adults (75 mg.) is

about six times the iron allowance. As with the mineral elements, there is increased need for vitamins during the growth period and in pregnancy.

The **standard allowances** for vitamins are usually several times the quantities that are necessary to prevent symptoms of a deficiency disease. This is because it has been shown that additional amounts, above those which will just prevent disease, bring returns in better growth of young animals or children and in increased vitality of adults. Usually from two to four times the minimum requirement will be found to be the OPTIMUM amount for positive health.

The recommended allowances of the Food and Nutrition Board, National Research Council, for different vitamins all allow a very liberal amount over and above MINIMUM requirement, in the effort to raise general health standards. However, when these optimum allowances are used as a "yardstick" for measuring whether diets are adequate, it should be remembered that usually far less than the recommended quantity will suffice to prevent symptoms of deficiency disease. For instance, 25 mg. (or less) of vitamin C (ascorbic acid) is enough to prevent scurvy but the recommended amount is 75 mg. The Board definitely states that it has set rather high standards as something to aim at, with the desire of raising the general nutritional level of the country.

General Uses of Vitamins in Body. While individual vitamins have special functions, which will be taken up in the following chapters, as a group of body regulators they share in certain functions, such as

(1) the promotion of growth
(2) the promotion of ability to reproduce healthy offspring
(3) the maintenance of health and vigor through promoting
    (a) normal functioning of the digestive tract
    (b) normal nutrition, especially utilization of mineral elements and oxidation of carbohydrates
    (c) nervous stability
    (d) health of tissues and resistance to bacterial infections

It is worth while to keep in mind the above GENERAL USES of vitamins, since they recur constantly in the study of the functions of individual vitamins. Also, it should be emphasized that, when several vitamins participate in promoting some function of the body, lack of any ONE of them will suffice to inhibit this function. For example, vitamins A, B_1, B_2, C and D all have a direct influence in stimulating growth. When any one of these vitamins is supplied in inadequate amounts, growth will be stunted, even though the food contains plenty of the other vitamins needed for growth. In similar manner, damage to reproductive ability, to functioning of the

digestive tract, and to the health of various tissues may result from lack of any ONE of several vitamins that are needed for the welfare of these organs or tissues.

Main Objective of Vitamin Knowledge. The chief aim of the study of vitamins is to see that human beings get plenty of ALL of the various ones needed to promote positive health. This should not be lost sight of in the maze of interesting scientific facts which research on vitamins has brought to light. The need for vitamins begins before birth, since it is important that the diet of a pregnant woman should be rich in vitamins if the infant is to start life with a liberal store of these substances in its body. Children must be liberally supplied with numerous vitamins in order to build healthy tissues and make the best growth. In adult life, a plentiful supply of all needed vitamins may mean better health and longer life. Although vitamin concentrates and pure, synthetic vitamins are very useful for the cure of the sick, the objective of nutrition is to have enough of all the needed vitamins IN THE DIET for PREVENTION of disease and promotion of health.

How to Get Plenty of Vitamins in the Diet. The most practical **general rule** for increasing the vitamin content of the diet is to take larger amounts of whole milk, whole grains, fruits and vegetables, along with some butter, eggs and meats (especially organ meats).

To safeguard both the vitamin and mineral content of the diet, the following **dietary pattern** has been suggested by the Food and Nutrition Board of the National Research Council:

MILK—2 or more glasses daily for adults; 3 to 4 or more glasses daily for children

VEGETABLES—2 or more servings daily besides potato; raw, green, and yellow vegetables should be served frequently

FRUITS—2 or more servings daily, one of which should be citrus fruit or tomato

EGGS—3 to 5 a week; 1 daily preferred

MEAT, CHEESE, FISH, OR LEGUMES—1 or more servings daily

CEREAL OR BREAD—Most of it whole grain or "enriched"

BUTTER OR FORTIFIED MARGARINE—2 or more tablespoons daily

Other foods will be needed to supply calories for growth and activity but, if a person gets the above-mentioned foods each day, there will be little danger of vitamin shortage. The foods which are chiefly responsible for supplying different individual vitamins will be made clear in the following chapters.

QUESTIONS

1. If vitamins are a group of unrelated organic compounds that are needed in small amounts for normal functioning of body tissues but cannot be made within the body, why are the essential amino acids and essential fatty acids not classed as vitamins? Why are the "trace" minerals, which are needed in very small amounts and must be supplied in food for normal body functioning, not included with the vitamins? Why are hormones, such as adrenalin and insulin, not called vitamins?

2. The rat and dog do not have to have ascorbic acid (vitamin C) supplied in their food, because they can make it in their own body tissues; men and guinea pigs cannot make this substance within their bodies, and hence must get it from foods. Could you say that ascorbic acid is a hormone for rats and a vitamin for man?

3. When was it first known that animals could not be maintained in health, or even survive, on diets of purified foodstuffs that provided plenty of calories, protein, and all necessary mineral elements? Approximately how long before it was recognized that natural foods provided traces of definite ORGANIC SUBSTANCES that were absent from the purified foodstuffs? When were these substances first called "vitamines?" Who first distinguished between two groups of these substances and called them "fat-soluble A" and "water-soluble B"?

4. Tell what is meant by the following terms that are used in connection with vitamins: biological assay, biological units, international units, U. S. Pharmacopeia units, vitamin concentrates, synthetic vitamins, a milligram, a microgram, minimum requirement, standard allowance.

5. Why were the vitamins designated by letters of the alphabet? In general, is it better to call a vitamin by its chemical name, when it has been given one, or by a letter, and why? Are letters more convenient in some cases, for instance vitamin A instead of axerophthol, vitamin E instead of α, β, and γ tocopherol? Why do we still speak of the group of vitamins D instead of calling them by chemical names? Can you give the chemical names for vitamins B_1, B_2, and C?

6. How can the vitamin content of foods be measured? From the directions on p. 209, as to how to get plenty of vitamins in the diet, what foods or classes of foods would you say are relatively rich in one or more vitamins? In what types of food are fat-soluble vitamins found? What classes of food are good purveyors of water-soluble vitamins? Name three foods that furnish considerable amounts of some water-soluble and fat-soluble vitamins together. Name five foods that carry little or no vitamins.

7. Give the general uses of vitamins in the body, *i. e.*, functions in which

several vitamins participate and to which all of them are essential. Would rats grow on a diet which furnished adequate energy, proteins, minerals, and all of the vitamins except vitamin A? Why? If both vitamins A and C help to prevent infections, would you expect to raise bacterial resistance satisfactorily by taking a diet rich in one of these vitamins and poor in the other?

8. Why is it important that the vitamin intake should be well balanced, *i. e.*, contain all of the essential vitamins in the approximate proportions in which they are required by the body? Why is it advantageous to get vitamins in natural foods instead of eating a vitamin-poor diet and taking synthetic vitamins in pills or capsules?

SUPPLEMENTARY READING

Sherman, H. C., SCIENCE OF NUTRITION, Chap. IV, "Introducing the Vitamins," pp. 37–43, Columbia University Press, 1943.

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Eddy, W. H., and Hawley, G. G., WE NEED VITAMINS, Chap. I, "What Are Vitamins," pp. 7–20, Reinhold Publishing Co., 1941.

McCollum, Orent-Keiles, and Day, NEWER KNOWLEDGE OF NUTRITION, 5th ed., Chap. II, "Nutritive Requirements of the Body, the Modern Concept of Dietary Essentials," The Macmillan Co., pp. 15–21 incl., 1939.

CHAPTER 14

ASCORBIC ACID (VITAMIN C)

THIS substance makes a good starting point for the study of individual vitamins, since (1) it was the first vitamin to be identified chemically, (2) it is the simplest of the substances now known to function as vitamins, (3) it is the most unstable of the vitamins, yet it is the one needed in largest amounts by man, and (4) the deficiency disease caused by lack of it has been known for centuries. As vitamins A and B (B_1) had been studied and christened before the vitamin activity of this substance was clearly established, it was given third place in the vitamin alphabet and designated as **vitamin C.** After its chemical structure was discovered, it became known as **ascorbic acid,** and the two terms may be used interchangeably.

Effects of Lack of Vitamin C. The set of symptoms that appears after the shortage of this vitamin were designated by the name of **scurvy** long before the cause of the disease was known. From records of the Crusaders, it is evident that they suffered from scurvy. This disease caused many deaths among crews of ships during the long voyages necessary in exploration of the New World that was opened by the discoveries of Columbus and other navigators. The lives of many of the men with the explorer Cartier, when obliged to spend the winter of 1535 in Canada, were saved because they learned from the Indians that a "brew" made from the growing tips of branches of the spruce and other trees was a cure for this malady. Fresh vegetables and citrus fruits were reported to be preventives against scurvy, and in 1757 Lind published experiments made on ships of the British Navy, which proved that lemons would prevent or cure this disease. However, 155 years more were to elapse before the potency of citrus fruits and fresh vegetables in preventing scurvy was explained as due to the presence of a vitamin in these foods.

SYMPTOMS of acute scurvy (caused by prolonged lack of vitamin C) are SWOLLEN AND BLEEDING GUMS, LOOSE TEETH, SORENESS AND STIFFNESS OF JOINTS, FRAGILE BONES, HEMORRHAGES UNDER THE SKIN and elsewhere, LOSS OF WEIGHT and GREAT MUSCULAR WEAKNESS, leading to death. Acute scurvy presents such a dramatic picture of degeneration in many body tis-

sues (teeth and gums, blood vessel walls, bones, cartilage and muscle tissues) that it is not difficult to recognize. As it is prevented by taking even moderate amounts of fresh or cooked fruits and vegetables, it is seldom seen now.

Less severe symptoms, known as SUB-ACUTE or LATENT SCURVY, still occur fairly often among infants, in districts (such as Labrador and Newfoundland) where fresh, raw foods are difficult to obtain, and when infection develops in persons who habitually take a diet low in vitamin C. In young children, symptoms of latent scurvy are FAILURE TO GROW properly, restlessness and irritability, sometimes swollen and painful joints. Signs of vitamin C deficiency in older children and adults are usually listlessness,



Fig. 23. Mouth of child with scurvy. Note the swollen and spongy gums, with soft tissues nearly obscuring the teeth in some places. (Gordon and Sevringhaus: Vitamin Therapy in General Practice, Yearbook Publishers, Inc.)

lack of endurance, fleeting pains in the legs and joints (often mistaken for rheumatism), small hemorrhages under the skin (Fig. 24), or spongy gums which bleed easily (Fig. 23).

Uses in the Body. The symptoms caused by lack of ascorbic acid give us clues as to its normal uses in the body, although the exact way in which it functions is still unknown. Sherman states[1] that "the nutritional functions of vitamin C which have thus far been most clearly established are (*a*) its relationship to the formation and maintenance of intercellular cement substance, (*b*) its significance in safeguarding the body through the blood, and (*c*) its rôle in regulating the rate of cellular respiration."

[1] Sherman, H. C., CHEMISTRY OF FOOD AND NUTRITION, 7th ed., p. 328, Macmillan, 1946.

The wide-spread tissue damage seen in scurvy makes it apparent that this vitamin is needed by many kinds of tissue, especially **connective tissue.** Vitamin C seems to play a necessary part in the formation and upkeep of substances that are responsible for "cementing" together cells in specialized tissues. When it is supplied in insufficient amounts, tissues in

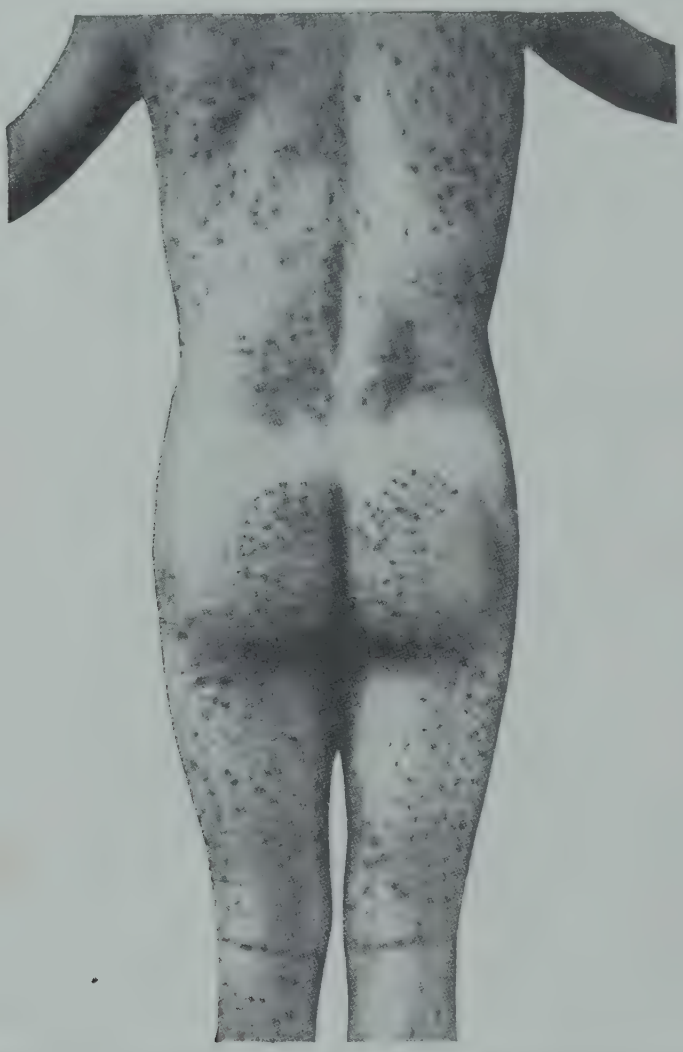


Fig. 24. A typical case of adult scurvy, showing the numerous petechiae—spots where blood has effused to the skin. (Harris, L. J.: Vitamins in Theory and Practice, 1937, Macmillan Co.)

widely distributed parts of the body may suffer—*e. g.*, BLOOD VESSEL WALLS become more fragile and are likely to "spring a leak"; there is damage to CARTILAGE, especially in the growing ends of bones (at joints), and BONES become less strong through degeneration of the bone matrix and loss of calcium. Anemia, often seen in scurvy, may be due to degeneration of the

bone marrow, which is charged with the formation of new red blood cells, to loss of blood by hemorrhage, or both. The TEETH, GUMS, and muscle fibers also suffer damage. Damage to the internal structure of the teeth is one of the earliest signs of ascorbic acid deficiency in guinea pigs, and the value of this vitamin in preventing systemic pyorrhea in man has also been demonstrated.[2]

The lessened strength of the blood vessel walls, as evidenced by a tendency to hemorrhages from small blood vessels in the skin, has been used

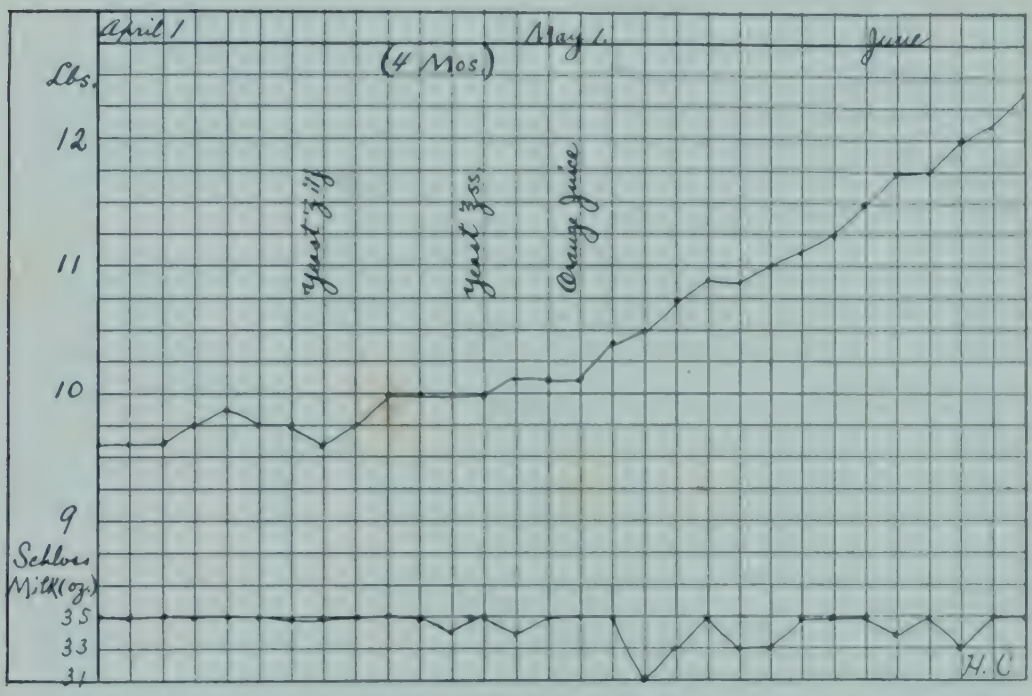


Fig. 25. Latent infantile scurvy, as shown by failure to gain weight promptly, yielding to orange juice after being uninfluenced by giving yeast. Orange juice is given as a source of vitamin C, and the prompt response of the infant by a gain in weight indicates that the previous condition was due to a lack of this vitamin. (From Hess, "Scurvy, Past and Present," J. B. Lippincott Co., Publishers.)

as a test for low-grade shortage of vitamin C, the so-called "CAPILLARY FRAGILITY TEST."[3]

This vitamin also functions, in some little understood way, in **protecting the body against infections and bacterial toxins.** Menton and King[4] fed guinea pigs graded amounts of ascorbic acid, and found that those which received lower intakes of this vitamin suffered greater injury

[2] Boyle, Bessey, and Wohlbach; J. Am. Dental A., v. 24, p. 1768, 1937.
[3] Göthlin, Skan. Arch. Physiol., v. 61, p. 225, 1931, and later papers.
[4] Menton, M. L., and Kling, C. C., J. Nutrition, v. 10, p. 141, 1935.

(loss of weight, etc.) from repeated doses of diphtheria toxin, even though they showed no signs of scurvy. Others have shown that guinea pigs on limited vitamin C intake succumb to inoculations with different strains of bacteria, which have little or no effect upon animals that received liberal quantities of this vitamin. The lowered resistance to infection in infants with scurvy is notable. It would seem that ascorbic acid combines with bacterial toxins, which are excreted in this combined form; hence infec-

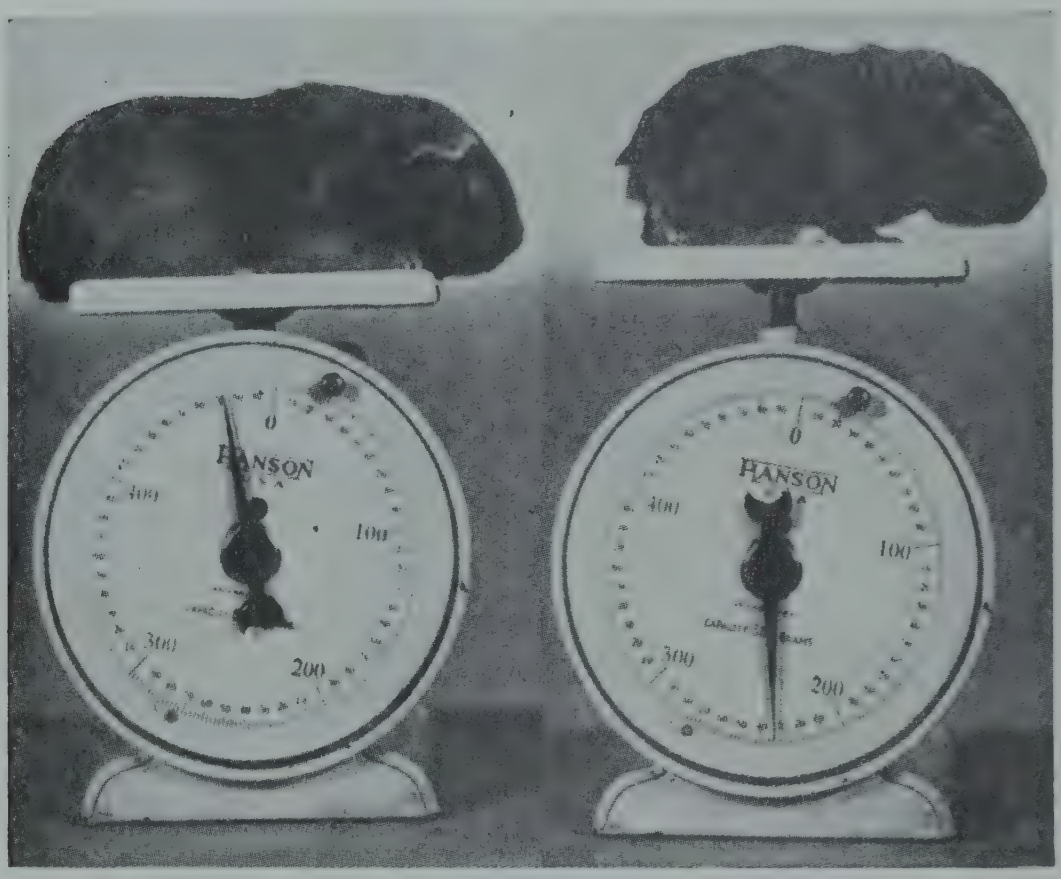


Fig. 26. Stunting of growth due to lack of vitamin C. The guinea pig on the right, which had a vitamin C-deficient diet, was in poor condition and weighed only 234 gms., while the left hand one on the same diet plus orange juice weighed 473 gms. (Courtesy Dr. J. G. Coffin, New York City.)

tions increase the need for this vitamin and rob the tissues of any reserve stores of it. So liberal intakes of vitamin C are recommended to enable the body to combat minor infections, while extra quantities are required in such diseases as tuberculosis, diphtheria and rheumatic fever.

Ascorbic acid also plays some rôle in the vital oxidation-reduction processes of the tissues, although the exact way in which it acts is not yet clear. Deficiency of this substance leads to increased up-take of oxygen both in

the intact animal and in excised tissues.[5] Sealock[6] has also shown that ascorbic acid is necessary for the normal metabolism of the amino acid tyrosine in guinea pigs. Thus vitamin C may prove to function in protein metabolism and there is some evidence that more of this vitamin may be needed when larger quantities of protein are consumed.[7]

Other recent work has stressed the relation of vitamin C to wound healing. Both animal and human studies[8] indicate that a sufficiently low dietary intake results in delayed healing and less strength of the healed wound, while giving extra ascorbic acid after operations promotes sound healing of wounds. Others have been unable to confirm these findings but it seems reasonable that vitamin C, which is known to be essential for formation of substances that cement cells together and of tendrils of connective tissue, would function in the reknitting of tissues in wound healing.

Chemical Identification and Properties. In 1932, Dr. C. C. King of Pittsburgh (now head of The Nutrition Foundation in New York) and the Hungarian scientist Szent-Györgyi almost simultaneously obtained pure preparations of this vitamin, the former from lemons and the latter from red peppers (also from adrenal glands). King announced, and Szent-Györgyi quickly confirmed, this substance to be a relatively simple organic acid with six carbon atoms in each molecule. Its chemical structure is somewhat similar to that of the simple sugars, which also are built on a chain of six carbon atoms. King gave it the name of **ascorbic acid,** indicative of the fact that it is a preventive for scurvy (the adjective from scurvy is scorbutic). After its chemical structure was known, it was soon possible to make this vitamin (from several six-carbon sugars) in the laboratory.

Ascorbic acid is a WHITE, CRYSTALLINE SOLID (see Fig. 27), which is readily SOLUBLE IN WATER. It is the most unstable of all the known vitamins, as it is EASILY OXIDIZED to another compound which lacks vitamin potency. By the loss of two hydrogen atoms per molecule, ascorbic acid is oxidized to the inactive dehydro-ascorbic acid, which can be reconverted into ascorbic acid by reduction (adding hydrogen). This is called reversible oxidation-reduction. In living plant and animal tissues ascorbic acid suffers little destruction, but in foods it is readily oxidized on exposure to air (especially since fruits and vegetables contain an enzyme that facilitates

[5] Stotz, King, *et al.*, J. Biol. Chem., v. 122, p. 407, 1938; Fidlar, Sheppard, and McHenry, Biochem. J., v. 33, p. 344, 1939.

[6] Lan and Sealock, J. Biol. Chem., v. 155, p. 483, 1944.

[7] Patterson and Bourquin, Am. J. Digest. Dis., v. 10, p. 390, 1943.

[8] Lund and Crandon, J.A.M.A., v. 116, p. 663, 1941; Bartlett, Jones, and Ryan, New England J. Med., v. 226, p. 469, 1942; Lund, *idem*, v. 227, p. 247, 1942.

this oxidation). Its destruction is much more rapid in solutions that are alkaline in reaction than in acid solutions.

There may be very considerable losses of this vitamin in foods during storage, processing (canning or drying), and cooking. The extent of these losses in vitamin C content will depend not only upon the reaction, but upon the length and degree of heating, especially upon whether the food is freely exposed to air and other factors. Exposure to sunlight and traces of copper or iron from metal containers also increase loss of vitamin C. Refrigeration during storage will reduce losses of ascorbic acid in foods, as will also the processing of canned foods in sealed containers from which air has been evacuated. Commercially canned foods may compare favorably in

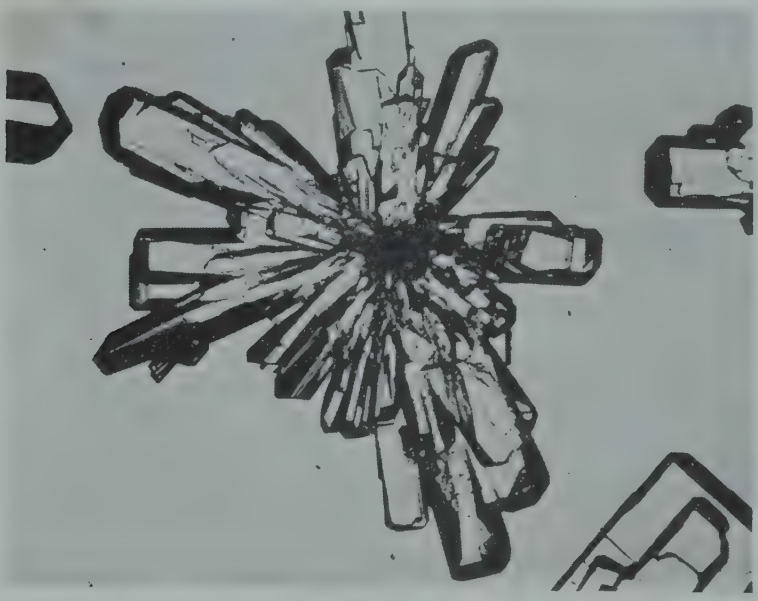


Fig. 27. Microphotograph showing the crystalline structure of pure ascorbic acid. (Courtesy of Merck and Company.)

vitamin C content with home-cooked products, if they reach the cannery fresh from nearby fields and are heated quickly in vacuum sealed cans. In acid foods (such as tomatoes and grapefruit juice) there are only minor losses of vitamin C in canning. Brief blanching with steam, followed by rapid drying (NOT exposed to sunlight), favors retention of ascorbic acid in dehydrated foods. Fruits that have been sulfured before drying retain a higher proportion of their original vitamin content than those that are unsulfured.

Since vitamin C is very soluble in water, considerable amounts of it may be lost in the water in which foods are cooked, or in the liquor of canned foods, if these are discarded.

Chemical methods for the determination of ascorbic acid in foods, blood plasma, urine, and animal tissues are based on the fact that it is readily oxidized. In being oxidized, it will reduce certain colored dyes to colorless substances. The amount of the "unknown" required to decolorize a known quantity of the dye serves as a measure of its vitamin C content.

Ascorbic Acid in Animal Metabolism. These chemical methods have made it possible to follow ascorbic acid into the body, to determine its LEVEL IN THE BLOOD and tissues, and the amount of it EXCRETED IN THE URINE. Man, monkeys, and guinea pigs are entirely dependent for vitamin C upon the amounts contained in their food, since they cannot make this substance in their bodies. All other animals can build ascorbic acid (probably from the intermediate products of sugar metabolism), so that they will not lack for this vitamin even when it is supplied in inadequate amounts by food. The discussion in the following paragraphs will be limited to ascorbic acid metabolism in man.

Vitamin C taken in the food is absorbed into the blood stream, chiefly from the small intestine, within a few hours after eating. The level of the ascorbic acid in the blood plasma is increased only temporarily, since this substance is taken up by the tissues and any excess is excreted promptly by the kidneys. Intravenously injected vitamin C is excreted within 1–3 hours. Although there is little ability to store ascorbic acid in the body, it is present in higher concentrations in glandular tissues, especially in the adrenal glands. The amount of this substance in the body tissues depends upon the quantity in the food, and upon the rate at which it is destroyed in and excreted from the body.

Under normal conditions, higher levels of daily intake of ascorbic acid result in increased amounts of it both in the body and in the urine. Conversely, low levels of vitamin C in the blood and urine indicate that the daily diet provides little of this vitamin. If a vitamin C-poor diet has been long continued, the tissues become unusually low in, and are said to be "unsaturated" as to, vitamin C. When higher intakes are given to such persons, the tissues will take up more vitamin C and abnormally low amounts will be excreted in the urine. If high intakes of vitamin C are continued until the tissues have become "saturated" with vitamin C, urinary excretion will then rise decidedly since the excess is excreted through this channel. This knowledge of the normal courses of vitamin C in the body has been established by experiments too numerous to quote.

Tests to determine whether or not an individual has been getting enough ascorbic acid in his diet for good nutrition ("nutritional status" tests) are based on the above facts. One test is to determine the LEVEL OF ASCORBIC

ACID IN THE BLOOD under the usual dietary conditions. Another way is to inject a sizable dose of ascorbic acid, after which the level of it in the blood is determined—the more unsaturated the tissues are as to vitamin C, the less of the injected dose will be left in the blood. A third form of test consists in following the amount of ASCORBIC ACID EXCRETED IN THE URINE after a considerable quantity of this substance has been taken by mouth. If the diet has been deficient in vitamin C, the tissues will take up most of

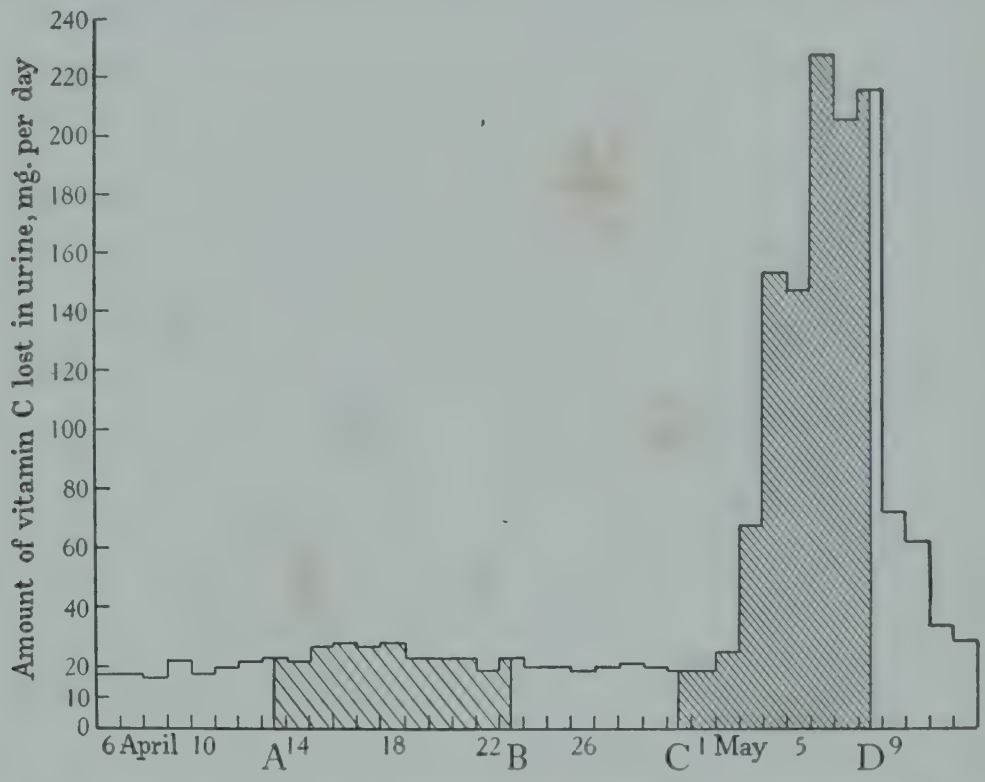


Fig. 28. Vitamin C in urine. The amount excreted in the urine depends on the amount given in the food and the degree of saturation of body tissues. The basal diet was poor in vitamin C; during first shaded period, 230 cc. of orange juice was taken daily but there was little increase in the amount of vitamin C in urine; the daily intake or orange juice was increased to 460 cc. during the second shaded period and greatly increased urinary output of vitamin C resulted. (From Harris, "Vitamins in Theory and Practice," Cambridge University Press, London, England.)

the quantity fed, so that there will be little excess to appear in the urine, and vice versa.

The results of such tests, made on many persons during recent years, make it clear that a large proportion of those tested had been getting less than "optimum" amounts of vitamin C in the diet. The number considered "deficient" will depend on how high a standard is set as normal. There is no evidence that SATURATION of the tissues with ascorbic acid is ESSENTIAL to health, but the tendency is to consider that larger intakes of this vitamin,

which make for higher concentrations of it in the body, are desirable from the standpoint of health.

Normal values for ascorbic acid in blood range from 0.7–1.2 mg. per 100 cc. of plasma;[9] values of 0.3–0.6 mg. indicate that vitamin C in the diet has been less than the desirable amounts, while levels less than 0.3 mg. per cent show a dangerous shortage of vitamin C, even though no definite symptoms of scurvy are apparent. Surveys on the level of ascorbic acid of the blood plasma of school children,[10] during months when fruits and vegetables are scarce, show that one half to two thirds of the apparently healthy children were receiving diets inadequate in vitamin C, while in approximately one third the shortage was of a degree dangerous to health. Others[11] claim that deficiency of this vitamin (as judged by saturation tests) is widespread among aged persons. Several surveys on the ascorbic acid status of college students, which are listed in the supplementary reading at the end of this chapter, indicate that considerable numbers are either on the borderline of adequacy or actually deficient as to vitamin C intake and level in the body.

Requirement and Standard Allowance. Probably only 15–25 mg. of vitamin C are needed to prevent scurvy, but the normal ADULT requires a daily intake of 60–75 mg. in order to maintain a fairly satisfactory level of ascorbic acid in the blood plasma. More is required if the goal is a complete saturation of the body with vitamin C. Todhunter and Robbins[12] found that a 60 mg. daily intake resulted in a fasting blood plasma level of 1.0–1.2 mg. per 100 cc., whereas 120 mg. daily did not quite suffice to keep the ascorbic acid of the plasma constantly at 1.4–1.5, the saturation level. They estimated that about 1.65 mg. per kg. of body weight is needed daily to maintain saturation in adults. This would mean 80–120 mg. of ascorbic acid in the diet each day (varying with body weight), and best distributed in 2 or 3 doses. There will be individual differences in body needs under normal conditions; any infection, even a slight cold, will increase the need for vitamin C considerably; severe muscular work is also thought to make an increased need for ascorbic acid, possibly because this water-soluble vitamin is lost in perspiration. CHILDREN and PREGNANT or LACTATING WOMEN have a high requirement for this vitamin.

[9] Ralli, E. P., and Sherry, S., Medicine, v. 20, p. 251, 1941; Bryan, A. H., Turner, D. F., *et al.*; Am. J. Med. Sc., v. 202, p. 77, 1941.

[10] Minot, A. S., Dodd, K., Keller, M., and Frank, H., J. Pediatrics, v. 16, p. 717, 1940; Holmes, F. E., Cullen, G. E., and Nelson, W. E., J. Pediatrics, v. 18, p. 300, 1941; Murphy, E., J. Nutrition, v. 21, p. 527, 1941.

[11] Rafsky, H. A., and Newman, B., Am. J. Med. Sc., v. 201, p. 749, 1941.

[12] Todhunter, E. N., and Robbins, R. C., J. Nutrition, v. 19, p. 263, 1940.

Standard **daily allowances**[13] for vitamin C are set at a moderately liberal figure, in order to provide a margin for variations in body needs, insure a sufficient surplus to promote health, and yet keep within limits of practicality and expense. They are as follows:

	Ascorbic Acid *mg.*		Ascorbic Acid *mg.*
Man (70 kg.)	75	Children, birth to 3 years	30–35
Woman (56 kg.)	70	Children, 4 to 12 years	50–75
Pregnancy (latter half)	100	Girls over 12 years	80
Lactation	150	Boys over 12 years	90–100

Distribution in Foods. For vitamin C we are dependent almost entirely upon FRUITS and VEGETABLES, and those which may be eaten FRESH and UNCOOKED are the best sources. Cooked and canned vegetables and fruits provide smaller and more variable quantities than the fresh ones. Even fresh fruits and vegetables show wide variations in their ascorbic acid content. The figures given in Table XVI represent only APPROXIMATE MEAN values. Milk contains small amounts of vitamin C but is an undependable source, especially if pasteurized. Much of the vitamin C in meats is destroyed in cooking; eggs, cereal grains, nuts, dried legumes, and dried fruits contain either very little or none.

Certain kinds of fruit and vegetables are unusually RICH in ascorbic acid. CITRUS FRUITS, STRAWBERRIES, LOGANBERRIES and CANTALOUPE lead the fruits in vitamin C content. TURNIP GREENS and KALE, PEPPERS, BROCCOLI, CAULIFLOWER, other leafy vegetables and members of the cabbage family, raw turnips, and tomatoes (either fresh or canned) are very good sources, even after cooking. Potatoes will contribute considerable amounts when eaten in large quantities.

Values for ascorbic acid content of RAW vegetables are given in the left-hand column on Table XVI on p. 223. Losses of vitamin C in cooking vary with the method and vegetable (especially its acidity). An allowance of 35 per cent loss is considered a fair average for most vegetables (unless baked, when loss is higher); for leafy vegetables, 45 per cent is average loss, for green and yellow vegetables 40 per cent, for boiling potatoes 20 per cent. Vitamin loss at the above average figures has been allowed for in the figures for cooked vegetables in the right hand column of Table XVI. Values for average servings of fruits are of FRESH RAW fruits; most fruits lose 30–40 per cent of vitamin C in cooking (80 per cent, if baked).

Canning losses vary widely with acidity, *e. g.*, string beans lose 75 per cent and tomatoes only 25 per cent of their vitamin C if properly canned. Quick freezing losses are of 30–40 per cent magnitude, incurred chiefly in washing, peeling, sorting and blanching fruit or vegetables preparatory to freezing.

[13] Recommended by the Food and Nutrition Board, National Research Council, 1948.

TABLE XVI. FRUITS AND VEGETABLES AS SOURCES OF VITAMN C

	Per 100 grams	Per average serving	
	Ascorbic acid	Measure of serving	Ascorbic acid
	mg.		*mg.*
Fruits, fresh		**Fruits, fresh**	
Strawberries	60	12 large strawberries	72
Oranges (or juice)	49	6 oz. orange juice (small glass)	90
Lemons (" ")	45	4 oz. lemon juice (½ cup, 8 tbsp.)	56
Grapefruit (or juice)	40	6 oz. canned juice or ½ med. large grapefruit	60
Cantaloupe	33	½ cantaloupe, 4½ in. diam.	50
Pineapple	24	⅔ cup pineapple, cubed	24
Berries (except strawberries and blueberries)	23	1 cup of berries	23
Honeydew melon	20	¼ melon, 5 in. diam.	20
Blueberries	16	⅔ cup blueberries	16
Avocados	16	½ avocado, 4 in. long	16
Cherries	14	½ cup pitted cherries	14
Bananas	10	1 medium-sized banana	10
Peaches	8	1 medium-large peach	8
Apples, Apricots, Grapes, Pears, Plums	4–6	1 medium or 2–3 small fruits (22–24 grapes)	5
Watermelon		Watermelon, 1 slice, 1½ in. thick, 6 in. diam. (600 gm.)	36
Vegetables, raw		**Vegetables, cooked**	
Turnip greens	136	½ cup cooked greens (100 gm.)	75
Peppers, green	115–120	1 medium pepper shell cooked	60
Broccoli		½ cup cooked broccoli	70
Kale		" " kale	63
Mustard greens, Collards	94–102	" " mustard greens or collards	55
Brussel sprouts		6 avg. Brussels sprouts, cooked (70 gm.)	38
Cauliflower	69	4 rounded tbsp. cauliflower, cooked (70 gm.)	32
Spinach	59	½–⅝ cup cooked spinach (100 gm.)	32
Cabbage	52	¾–1 cup cooked cabbage (100 gm.)	30
Chard, Dandelion greens	34–38	½ cup cooked chard or dandelion greens	20
Beet greens		½ cup cooked beet greens	19
Rutabagas		½ " " rutabagas	20

TABLE XVI (*continued*)

	Per 100 grams	Per average serving	
	Ascorbic acid	Measure of serving	Ascorbic acid
	mg.		*mg.*
Vegetables, raw (cont.)		**Vegetables, cooked** (cont.)	
Asparagus		6 stalks asparagus, cooked (50 gm.)	20
Beans, lima, green		½ cup cooked lima beans (100 gm.)	19
Okra	28–33	5–6 pods cooked okra (50 gm.)	10
Turnips		½ cup cooked turnip, cubed (100 gm.)	16
Peas, green	26	½ " " green peas (100 gm.)	16
Radishes		3 radishes, 1 in. diam., raw (28 gm.)	7
Sweet potatoes	23	1 medium sweet potato, cooked (125 gm.)	17
Tomatoes (or juice)		1 medium *raw* tomato (100 gm.)	23
		½ cup canned or cooked tomato	16
Beans, string, green		½ cup cooked string beans or ½ large parsnip (100 gm.)	12
Parsnips		½ cup cooked summer squash	10
Squash, summer	17–19	3 large green lettuce leaves, *raw* (50 gm.)	10
Lettuce, green		1 medium potato, cooked in skin	12
Potatoes		⅝ cup diced beets, cooked	6
Beets		½ cup canned corn or 1 med. ear, cooked	5–7
Corn, sweet	9–12	1 large or 2–3 small onions, cooked	6
Onions, mature		⅕ head lettuce (bleached, 50 gm.)	4
Lettuce, headed		½ med. cucumber, *raw*, or 8 slices (50 gm.)	4
Cucumbers	8	½ cup cooked winter squash (100 gm.)	5
Squash, winter		2 stalks or hearts of celery, *raw* (50 gm.)	4
Celery		¾ cup cubed carrots, cooked (100 gm.)	4
Carrots	5–7	½ cup cooked eggplant (100 gm.)	3
Eggplant			

Conserving Vitamin C in Foods. It is foolish to allow vitamin C, valuable for health, to be lost before foods are served on the table. As this is the most easily destroyed of the vitamins (and the one needed in largest quantities), its conservation presents a special problem. Reasons for the following special PRECAUTIONS in handling fresh fruits and vegetables should be self-evident if one keeps in mind that vitamin C is water soluble and easily destroyed by oxidation, while heat, alkaline reaction and, above all, exposure to air hasten its destruction:

Buy fresh fruits and vegetables in small enough quantities so that they will be used promptly; keep them at low temperature (in refrigerator, if possible).

Prepare them (paring and cutting up) immediately before they are to be cooked or served raw; do not let them stand in water or exposed to air before cooking, serve promptly, DO NOT KEEP HOT FOR LONG (or reheat) before serving.

Cook in as small a quantity of water and for as short a time as feasible; cook by steaming, or broiling (instead of boiling) and with "skins" left on when possible; if pressure cooker is available, the shorter time of cooking and limited exposure to air will help conserve vitamin C; keep cooking vessels tightly covered.

Never add soda in cooking vegetables or cook in copper container (presence of either alkali or copper hastens vitamin destruction).

Do not allow "quick-frozen" foods to thaw out before cooking; keep them in refrigerator and start cooking in frozen state in boiling water.

Juices of fresh fruits are best prepared immediately before serving and slightly more vitamins (and minerals) are obtained if they are not strained. However, acid juices (orange, grapefruit, tomato) may be left in a covered glass container in the refrigerator over night with little loss in vitamin C value; do NOT keep them in a metal container, even for a short time, after opening.

How to Get Standard Allowance in Diet. The following general rules will safeguard the diet as to vitamin C:

Take at least one food RAW each day, preferably both a green salad and fresh fruit.

Have one serving of CITRUS FRUIT or TOMATO daily (or other RICH source of vitamin C).

Use other fruits and vegetables as freely as possible.

The "DIETARY PATTERN," given on p. 209, calls for two servings of vegetables daily besides potato, with green and leafy vegetables frequently. These vegetables together with one serving of fresh fruit may be counted on to furnish 35–50 per cent of the daily quota of ascorbic acid for an adult (75 mg.). The other 50–65 per cent should be provided by some food es-

FOODS WHICH WILL FURNISH

50 mg. Ascorbic acid (QUOTA FOR 4–6 YR. OLD CHILD)	75 mg. Ascorbic acid (ADULT QUOTA)	100 mg. Ascorbic acid (QUOTA FOR ADOLESCENT BOY OR PREGNANT WOMAN)
Any one of the following:	All of the following:	One of the following:
$3\frac{1}{2}$ oz. ($\frac{1}{2}$ c.) fresh orange juice	Tomato, 1 fresh or $\frac{1}{2}$ c. canned	7 oz. orange juice
5 oz. (10 tbsp.) canned grapefruit juice	Potato, 1 cooked	$\frac{3}{4}$ c. cooked turnip greens
10 oz. ($1\frac{1}{4}$ c.) tomato juice, fresh or canned	Root vegetable, 1 average serving	$\frac{3}{4}$ c. cooked broccoli
	Leafy vegetable, $\frac{1}{2}$ c. (except those very high in vitamin C), cooked	
	Fresh fruit (not citrus), average serving	

pecially rich in vitamin C, such as citrus fruit or tomato. A small (6 oz.) glass of orange juice will furnish more than the daily adult quota of ascorbic acid, and the same quantity of tomato juice will provide half enough for the day's need.

QUESTIONS AND PROBLEMS

1. When, by whom, and from what materials was vitamin C first isolated as a pure substance? What type of a chemical compound is it? Why was the name ascorbic acid given to it? Where does it occur in nature? In the human body? What is the source of the pure ascorbic acid bought in tablet form at drug stores? Is it the same as naturally occurring ascorbic acid? How stable is this substance when kept in dry, solid form? In water solution with alkaline reaction? In acid solution? What other conditions affect its stability, and why?

2. Why was scurvy a very prevalent disease among crews on long sea voyages and early explorations? Why is it now possible for Admiral Byrd to take men into the Antarctic for long periods without fear that any of them may succumb to scurvy? What foods, or other substances, were known to prevent or cure scurvy long before it was recognized that their efficacy in this respect was due to the presence in all of them of a definite compound that might be classed as a vitamin? Give the symptoms of acute scurvy and explain the widespread tissue damages in the light of one of the chief functions of vitamin C in the body, *i. e.*, the formation and maintenance of intercellular and connective tissue substances.

3. Why do men and guinea pigs develop scurvy when the diet is lacking in ascorbic acid, while dogs, rats, and other animals do not? Do plants need ascorbic acid, and if so, how do they get it? Give three characteristic symptoms of subacute or latent scurvy in infants, three symptoms in adults that indicate the diet has furnished too little vitamin C. From consideration of the results of lack of this vitamin, what would you conclude are its main uses in the body?

4. Outline three tests that may be used to determine the level of ascorbic acid in the body, as an index of whether or not this vitamin has been supplied in adequate amounts by the diet. If the ascorbic acid content of the blood plasma is below normal, does this necessarily mean that there is little or none of this substance in other body tissues? What test or tests will indicate the "degree of saturation," or extent of depletion, of the tissues with respect to ascorbic acid? How important for health is it that the level of ascorbic acid in the blood and tissues should be at least fairly high, and why?

5. What classes of foods contribute little or no vitamin C in the diet, at least in the condition in which they are eaten? What classes of foods furnish the major part of the vitamin C intake? Consult Table XVI on pages 223-224 and list the five fruits and five vegetables richest in ascorbic acid in the raw state. List the ten that have the next highest ascorbic acid content per 100 gm., either fruits or vegetables, in order of their relative vitamin C content when raw. Rearrange these 20 fruits and vegetables in the order of the vitamin C contribution that will be made by an AVERAGE SERVING of each, fruits raw and vegetables with average allowance for loss of vitamin C in cooking, as given in the final column of Table XVI.

6. What is the recommended daily allowance of ascorbic acid for a normal woman? For a 12-year-old boy? For a pregnant woman? Why is the need for this vitamin relatively higher in childhood? In pregnancy and lactation? If 25 mg. ascorbic acid will protect an adult against scurvy, what is the use of taking three times this amount? Since foods that carry vitamin C are often fairly expensive and excess of it above body needs is excreted in the urine, is there any point in taking about twice the recommended allowance (150 mg.) daily? Is a high level of vitamin C intake practical, considering cost and size of servings of foods needed to provide this vitamin in large amounts?

7. List five foods that will provide ascorbic acid at low or moderate cost. Plan a day's diet, at low or moderate cost, that will furnish about 75 mg. of ascorbic acid for an adult, following the dietary pattern given on p. 209.

8. Plan a day's meals for yourself with some food that is a good source of vitamin C in each meal. Compute how many milligrams of vitamin C this diet will provide and compare with the standard allowance.

9. Give rules for conserving vitamin C in foods during storage and preparation for the table. What is the average range of losses of this vitamin in cooking fruits and vegetables?

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CHAPTER 15

B-COMPLEX VITAMINS

THIAMINE (vitamin B_1) made its debut as a recognized "food hormone" or vitamin about 1911. Much biochemical and clinical research preceded the establishment of its identity.

THIAMINE (VITAMIN B_1)

Research led to its discovery from two entirely different angles: (1) as a preventive for the disease **beriberi,** which had occurred among rice-eating peoples of the Orient for centuries, and (2) as a water-soluble constituent of foods that is essential for **growth** of animals. Later this growth-promoting factor (found in wheat germ and protein-free milk) was proved to be identical with the anti-beriberi factor (obtained from rice polishings and yeast). The first pure preparation of this substance was secured in 1926, but establishment of its chemical identity was not complete until 1936, when Dr. R. R. Williams (formerly in the Philippine Bureau of Sci-

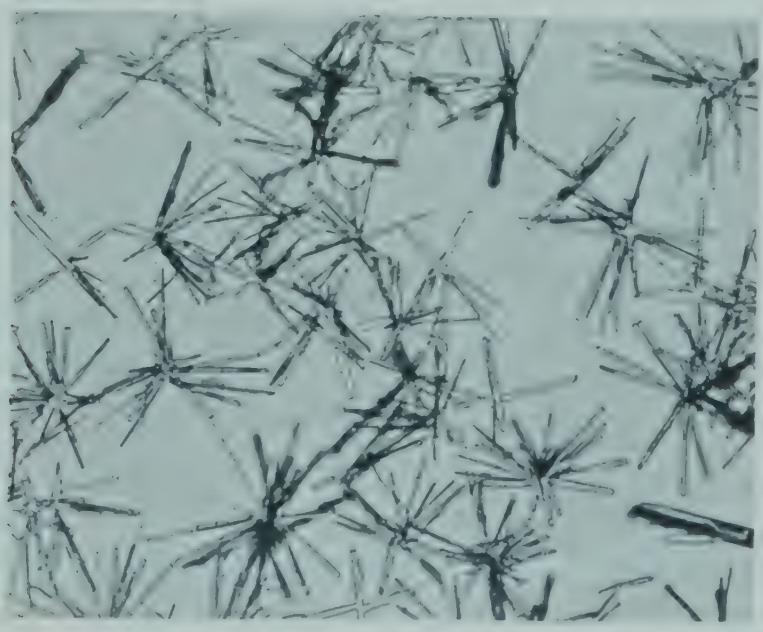


Fig. 29. Vitamin B_1, crystalline form. (Courtesy of Merck & Co., Inc.)

ence and later head of the Bell Telephone Laboratories) first made it synthetically and gave it the name, **thiamine.**

Thiamine is a crystalline substance, made up of the elements carbon, hydrogen, oxygen and sulfur, readily soluble in water and slightly so in



Fig. 30. Characteristic attitude of pigeon with polyneuritis (avian beriberi) after three weeks' feeding with a diet of "polished" rice. The pigeon was used year after year as a class demonstration and the extreme effect passed off within a few hours after feeding foods rich in vitamin B_1. (Morse "Applied Biochemistry.")



Fig. 31. Pigeon shown in Fig. 30 three hours after feeding substance rich in B_1 (rice polishings, yeast, etc.). Recovery seemed to be complete in twelve hours (Morse "Applied Biochemistry.")

alcohol. Although it is much less sensitive to oxidation than is ascorbic acid (vitamin C), it may be destroyed by heating in solution, especially prolonged heating at high temperatures, or in neutral or alkaline solution. Synthetic vitamin B_1 is usually prepared in the form of a salt, thiamine hydrochloride, which is more stable than the free vitamin.

Beriberi. Although this disease had been described in Chinese medical literature in times before Christ, its cause was not known to be related to the diet until early in the twentieth century. It was eradicated from the Japanese navy about 1884 by simple changes in diet, and in 1897 a Dutch



Fig. 32. Case of dry beriberi, showing atrophy of the muscles due to paralysis of the legs. (From Herzog, in Philippine Journal of Science.)

physician in Java (Eijkman) showed that a similar disease appeared in fowls fed nothing but polished rice. Working from these clues, numerous research workers in Java and the Philippines proved conclusively that human beriberi occurred on diets which consisted largely of polished rice and could be prevented by the substitution of brown rice, whole barley, or

dried legumes for part of the polished rice. Still later, the beriberi-preventing substance was extracted from rice bran or yeast (it took half a ton of rice bran or a ton of yeast to yield about 1 gram of fairly pure vitamin), and these concentrated preparations were very effective in causing symptoms of beriberi in human beings (or of the similar disease, polyneuritis, in fowls) to disappear. Beriberi was thus shown to be due to lack of a substance that is contained in the germ and outer coats of grains but almost



A B

Fig. 33. A, Swelling of the legs and marked pitting edema in the ankle region in patient with thiamine deficiency. B, Same patient as in A, ten days after the initiation of thiamine therapy, during which the patient lost 40 pounds in weight. Presumably this weight loss was due to loss of fluid since his general nutritive state was greatly improved. (From Spies, "Rehabilitation" Through Better Nutrition.)

entirely absent in polished rice or highly milled cereals. This substance came to be known as the "antineuritic" vitamin, vitamin B_1, or thiamine.

The **symptoms** of beriberi are numbness or tingling in toes and feet, stiffness of ankles and absence of "ankle jerk" reflex, cramping pains in legs, difficulty in walking, and finally paralysis of legs with atrophy of leg muscles (see Fig. 32). In later stages, various nerves in the upper part of the body may be affected and disturbances of heart function are common. In the form known as WET beriberi, dropsical bloating or edema (especially of legs) is a complicating factor (see Fig. 33).

Functions of Thiamine in Normal Nutrition. Although American diets provide enough vitamin B_1 so that beriberi is seldom seen in this country, the extensive tissue damage that occurs in this disease, due to lack of thiamine, makes us realize that this vitamin must play an important role in normal nutrition.

It is present in most plant and animal tissues. Plants and some microorganisms are able to synthesize vitamin B_1, which is needed to promote their growth. Bacteria in the intestinal tract of rats, cattle, sheep, and to some extent also in man, can make this vitamin, but for the most part man and other animals must obtain it preformed in food. Although there is



Fig. 34. Effects upon growth of feeding four different levels of thiamine. (From experiments by Dr. Bertha Bisbey.)

little ability to store thiamine in animal tissues, it is present in small amounts in practically all tissues and in somewhat higher concentration in such organs as heart, liver and kidneys.

Thiamine was early shown to be essential for **growth** of animals, and later was established as needed for successful **reproduction.** Growth is proportional to the amount of it that is fed (see Fig. 34), up to a certain level. Numerous pediatricians have reported failure to grow properly and symptoms that indicate vitamin B_1 lack in both artificially fed and breast-fed infants from five to ten months old. The diet of these babies had been considered adequate and they received orange juice and cod liver oil (for vitamins C, A and D). Growth was accelerated and general health much

improved when wheat germ or yeast extract, or synthetic thiamine, was given either to the mothers of nursing babies or directly to the child.[1] Neither cow's nor human milk is a very good source of this vitamin; the amount in the milk depends on the sources of vitamin B_1 in the maternal diet and less than half of the vitamin fed is transferred to the milk.[2] Hence the safest course is to give the vitamin directly to the baby. It has been recommended[3] that "just as regularly as orange juice and cod liver oil are prescribed one should also prescribe a substance rich in vitamin B_1 for the infant dietary." Older children have also been shown to make better growth when the diet was reinforced by foods rich in this vitamin.

Thiamine also plays a part in promoting **appetite** and better functioning of the **digestive tract** (effects that have an indirect influence in promoting growth). Cowgill[4] showed that dogs fed a vitamin B_1-deficient diet soon refused to eat and that, at the same time, there was a marked decrease in the muscular tone and motility of the stomach and intestines; administration of thiamine, either by mouth or by injection into the blood, promptly restored normal appetite and digestive functions. This has since been confirmed by many investigators, both for other animals and for man.[5] The emptying time of the stomach and intestines has been shown to be nearly twice as slow in thiamine-deficient animals as in normal ones, and this vitamin has been of assistance in relieving stubborn cases of constipation. Perhaps it should be emphasized that the specific effect of vitamin B_1 on appetite is exerted only when there has been a deficiency of it in the diet and then only to the extent of restoring NORMAL appetite; large quantities of the vitamin will not promote a voracious appetite, and other factors may be responsible for loss of desire for food.

Foremost among the uses of thiamine is the part that it plays in the life processes of individual cells throughout the body. Most of the energy for the life processes of body tissues comes from the oxidation of carbohydrate, which takes place gradually through the formation of intermediate

[1] Hoobler, B. R., "Symptomatology of Vitamin B Deficiency in Infants," J.A.M.A., v. 91, p. 307, 1928.

Clements, F. W., "Symptoms of Partial Vitamin B_1 Deficiency in Breast-fed Infants," M. J. of Australia, I, p. 12, 1942.

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[2] Review, "Thiamine in Human Milk," Nutrition Rev., v. 1, p. 270, 1943.

[3] Hoobler, reference cited.

[4] Cowgill, G. R., Rosenberg, H. A., and Rogoff, J., Am. J. Physiol., v. 96, p. 372, 1931.

[5] Schultz, F. W., and Knott, E. M., "The Effect of Varied Vitamin B Ingestion upon the Appetite of Children," J. Nutrition, v. 15, p. 411, 1938.

products and requires enzymes[6] to bring about or catalyze each step of the intricate process. Some of the enzymes require co-enzymes to render them active, or capable of bringing about a certain chemical change. Thiamine has been shown to be the active part of a co-enzyme which is necessary for the further oxidation of pyruvic acid, one of the intermediate products of carbohydrate oxidation. Hence it is an essential link in the chain-like process of passing along oxygen to the tissues and must be provided for the complete oxidation of carbohydrate. As this thiamine-containing co-enzyme aids in the oxygen up-take of all kinds of tissues, an insufficient supply of thiamine may result in faulty functioning of various tissues, and an extra supply of this vitamin may cause quick restoration of their normal functioning. Nervous tissue is especially dependent upon carbohydrate oxidation for its life processes and so is one of the first to show effects of thiamine lack in faulty functioning.

Thiamine has been called "the morale vitamin," since the earliest signs of its lack show in a lowering of nervous stamina. Scientific studies[7] of people who volunteered to consume a diet moderately low in vitamin B_1 demonstrated that, after a very short time on such a diet, the subjects became DEPRESSED, IRRITABLE, LACKING IN ABILITY TO CONCENTRATE on and take interest in their work. In three to seven weeks, such symptoms as FATIGUE, LACK OF APPETITE, LOSS OF WEIGHT, CONSTIPATION, muscle cramps, and various NERVOUS PAINS appeared. The subjects promptly recovered normal health and morale when given larger amounts of thiamine. Freely chosen human diets, which are low in thiamine content, often furnish too little of other B-complex vitamins as well, and in such cases several of the B vitamins may be needed before relief from all deficiency symptoms is obtained.

Thiamine in the Body. This substance, which is so essential for health, exists in raw and unrefined foods in amounts that range from 2 parts per 10 million to 14 parts per million. Its activity in the body is dependent on the fact that it undergoes reversible oxidation-reduction, and this in turn is probably due to the sulfur-containing group in its molecule. There are only two vitamins that contain sulfur, thiamine and biotin, another of the B-complex group.

[6] An enzyme is an organic substance produced by a living cell, which facilitates some chemical reaction without itself taking an active part in it. For a fuller description of enzymes and their mode of action, see p. 321.

[7] Melnick, D., *et al.*, J. Nutrition, v. 18, p. 593, 1939; Jolliffe, N., *et al.*, Am. J. M. Sc., v. 198, p. 198, 1939; Williams, R. D., *et al.*, Arch. Int. Med., v. 69, p. 721, 1942, and v. 71, p. 38, 1943; Hulse, M. C., *et al.*, Ann. Int. Med., v. 21, p. 440, 1944.

Thiamine in the food is absorbed from the intestine and carried in the blood to the tissues. LIMITED quantities of it may be stored in the liver, kidneys, heart, muscles and brain, but only enough to maintain proper life for a few days, so that fresh supplies are needed daily. The thiamine-containing substance which assists in oxidation of carbohydrate is made by tissue cells, and carried in the blood chiefly in the nucleated white cells, with free thiamine in the plasma. The tissues take up only as much as they need and, since it is freely soluble in water, most of the thiamine intake not required for day-to-day uses is EXCRETED AS SUCH IN THE URINE.

Measurement of Requirement and Nutritional Level. It is impossible to give any exact figure for the vitamin B_1 need of adults, since the amount required will vary according to size, degree of activity, and dietary habits. As this vitamin takes part in the metabolism of carbohydrate, more of it will be needed when carbohydrate metabolism is high. PERSONS WHO DO MUSCULAR WORK burn up more fuel foods and usually take much of this extra fuel in the form of starchy foods, hence they need more thiamine than those who are muscularly inactive. The proportion of starchy foods and sweets in the diet also varies with different people. The requirement for vitamin B_1 is often stated in terms of the caloric intake (so much for every 1000 calories) or of the non-fat calories of the diet. GROWING CHILDREN have higher fuel needs, and so higher vitamin B_1 needs, per unit of body weight than adults. Women in the latter half of PREGNANCY and NURSING MOTHERS should have from one and one-half to two times as much thiamine as at other times.

Then, too, there is considerable difference of opinion as to what constitutes an adequate supply of this vitamin. Some investigators feel that an intake just sufficient to ward off any symptoms of mild deficiency is enough; others believe that a more liberal allowance is desirable and will yield benefits in better health. The level of MINIMUM REQUIREMENT has been variously set[8] at from 0.23 to 0.65 milligrams per 1000 calories, which would mean that a sedentary man or woman on an average diet that furnished 2500 calories, according to the lower figure should have a total of 0.5 mg., and at the higher figure 1.5 mg. thiamine daily. Wilder[9] has stated

[8] Elsom, K. O., *et al.*, Am. J. M. Sc., v. 203, p. 569, 1942; Melnick, D., J. Nutrition, v. 24, p. 139, 1942, and J. Am. Diet. A., v. 20, p. 516, 1944; Holt, L. E., Pennsylvania M. J., v. 46, p. 451, 1943; Keys, A., *et al.*, J. Nutrition, v. 26, p. 399, 1943; Williams, R. D., Wilder, R. M., *et al.*, Arch. Int. Med., v. 69, p. 721, 1942 and J. Nutrition, v. 25, p. 71, 1943; Alexander, B., and Landwehr, G., J. Clin. Investigation, v. 25, p. 287, 1946.

[9] Wilder, R. M., Arch. Int. Med., v. 14, p. 2189, 1941.

that 1.2 mg. daily are needed to insure health and that, to allow for failure of all the thiamine in foods to be absorbed from the intestine, 2.0 mg. daily should be provided for safety. Thus it will be seen that some recommend as OPTIMUM a thiamine intake which is 3–4 times higher than that which others regard as adequate.

The Food and Nutrition Board of the National Research Council has recommended (1948) a moderately liberal daily intake of vitamin B_1, varying with age, size, and activity, as given below:

Sedentary man, or Moderately active woman	1.2 mg. thiamine daily
Very active woman, or Moderately active man	1.5 " " "
Very active man	1.8 " " "
Pregnancy (latter half)	1.5 " " "
Lactation	1.5 " " "
Children under 3 yrs.	0.4–0.6 " " "
4– 9 yrs.	0.8–1.0 " " "
10–12 yrs.	1.2 " " "
Girls over 13 yrs.	1.2–1.3 " " "
Boys over 13 yrs.	1.5–1.7 " " "

Dietary surveys have shown that the average intake of vitamin B_1 is much nearer the minimum than the optimum level. Williams and coworkers[10] conclude that the average American diet, prior to the introduction of "enriched" bread, provided only about 0.8 milligrams thiamine per 2500 calories, which would be dangerously near the minimum requirement. The substitution for plain white bread of bread enriched with vitamin B_1 at government standards would increase the average daily thiamine intake from 0.8 mg. to 1.3 mg., which is much nearer the optimum level.

Chemical tests have been developed by means of which it is possible to determine whether a person has been getting plenty of or much too little thiamine in the diet, *i. e.*, to measure the "**nutritional level**" of the body as to vitamin B_1. If the diet has been deficient in this vitamin for a considerable period, there will be abnormally low amounts of thiamine in the urine, as well as decreased amounts of the thiamine-containing enzyme (co-carboxylase) and increased quantities of pyruvic acid (the intermediate product that thiamine helps to oxidize) in the blood. The percentage of a test dose of thiamine which is excreted in the urine (in 24 hours) also will indicate approximately the extent to which the tissues are either in need of or "saturated" with this vitamin. However, chemical methods for deter-

[10] Lane, R. L., Johnson, E., and Williams, R. R. J. Nutrition, v. 25, p. 613, 1942.

mining vitamin B_1 are not so exact as those for vitamin C, and the levels of thiamine in blood and urine are not so reliable an index of borderline deficiency of this vitamin in the body.

Thiamine in Foods. This vitamin is widely distributed in natural foods, but is present only in small amounts in watery fruits or vegetables and in refined cereals, while it is completely lacking in pure sugar and fats. Foods relatively rich in thiamine, which we use in quantity in modern diets, are rare. Tisdall said[11] in 1935 that more than half of the foods in the American diet contained very little vitamin B_1. Thiamine deficiency was almost nonexistent among Occidental peoples when whole grain breads were commonly used. Since thiamine occurs almost entirely in and about the germ of the wheat kernel (see Fig. 3, p. 19), MODERN MILLING, in which the germ and outer layers of grains are discarded, REMOVES ABOUT $\frac{7}{8}$ OF THE VITAMIN B_1 FROM WHEAT.[12] This is serious when white bread or cereals may furnish 25 per cent, or more, of the total caloric intake and sugar (totally lacking in B_1) also occupies a prominent place in the diet.

Accordingly, United States government authorities, in cooperation with the milling industry, in 1940 sponsored a program to add thiamine (along with two other B vitamins and iron) to highly milled "patent" flour. Bread made from such flour is said to be "enriched", and highly milled breakfast cereals, to which B vitamins and iron have been added about up to the level found in whole grains, are said to be "restored." By the end of World War II, most of the white bread sold in this country was of the "enriched" variety[13] and numerous states had laws requiring this type of white bread. Great Britain met her war-time wheat problem by adopting "national whole meal," a flour in which 85 per cent of the whole grain is retained. Several American nutritionists feel strongly[14] that whole grain bread and cereals have better nutritive value than highly milled ones to which a few vitamins and minerals have been restored (see discussion of milling of cereals, pp. 18–19).

Moreover, we must allow for LOSSES OF THIAMINE IN COOKING. Meats have been shown to suffer about 40–60 per cent loss of vitamin B_1 during roasting, while in boiling vegetables combined losses due to heat and solution in water may be as high as 37 per cent of the original B_1 content.[15] In baking bread, not more than 15 per cent of its thiamine content suffers de-

[11] Tisdall, F. F., J.A.M.A., v. 105, p. 1580, 1935.

[12] Schultz, A. S., Atkin, L., and Frey, C. N., Cereal Chem., v. 16, p. 1643, 1939; Williams, R. R., *idem.*, v. 16, p. 301, 1939.

[13] For enrichment standards, see National Research Council Bulletin No. 110, 1945.

[14] Lepowsky, S., Physiol. Rev., v. 24, p. 239, 1944.

[15] Aughey, E., and Daniel, E. P., J. Nutrition, v. 19, p. 285, 1940.

TABLE XVII. APPROXIMATE THIAMINE CONTENT OF TYPICAL FOODS

Food.	Thiamine, mg. per 100 gm. raw food, edible portion.*	Per Average Serving.	
		Size of Serving.	Thiamine, milligrams.†
Meats:			
Pork, lean	.920	Pork, 3½ oz. (100 gm.) roasted	.550
Organs, heart	.540		
liver	.270	Liver, beef, 2 oz., fried	.140
kidney	.160		
Lamb, lean	.200	Lamb, lean, 3½ oz., roasted	.120
Veal, lean	.180		
Beef, lean	.140	Beef, lean, 3½ oz., broiled	.100
Oysters	.130		
Chicken	.110	Chicken, 3½ oz., roasted	.066
Fish, med. fat	.070	Fish, 3½ oz., fried	.060
Legumes and Nuts:			
Dried, soybeans	1.140	Dried soybeans (30 gm.), ½ c. cooked	.200
other beans	.600	navy beans, ½ c. cooked	.100
split peas	.870	navy beans, ½ c. canned	.050
Fresh, green peas	.360	Fresh green peas, 100 gm., ½ c. cooked	.250 (canned .110)
lima beans	.250	Fresh lima beans, 100 gm., ½ c. cooked	.175
Peanuts, roasted	.300	Peanut butter, 30 gm., 2 tbsp.	.060
Other nuts	.250–.720	Other nuts, 30 gm., 24–30 nuts	.070–.210
Cereal Products:			
Bread, whole wheat	.280	Bread, whole wheat, 1 slice	.078
white, enriched	.240	white, enriched, 1 slice	.060
white, unenriched	.068	white, unenriched, 1 slice	.017
Cereals, whole wheat, dry	.450	Whole wheat cereal, ¾ c. cooked	.135
oatmeal, dry	.550	Oatmeal (30 gm. dry), ⅔ c. cooked	.165
farina, enriched	.370	Cream of wheat, enriched, ¾ c. cooked	.132
farina, unenriched	.060	Cream of wheat, unenriched, ¾ c. cooked	.018
Eggs	.120	Egg, 1 whole, boiled	.082
Cheese, Am. cheddar	.040	Cheese, Am. cheddar, 1 oz.	.012
Milk, whole, fresh	.040	Milk, whole, fresh, 1 pint	.190
Vegetables:			
Potatoes	.110	Potato, 1 medium (100 gm.) boiled	.082
Leafy, avg.	.110	Leafy, ½ c. cooked (100 gm.)	.082
Others, except legumes, avg.	.070	Others (exc. legumes), ½ c. cooked	.052

TABLE XVII. (*Continued*)

Food.	Thiamine, mg. per 100 gm. raw food, edible portion.*	Per Average Serving.	
		Size of Serving.	Thiamine, milligrams.†
Fruits:			
Fresh, avg.	.050	Fruit, fresh, avg., 100 gm., raw.	.050
Dried, avg., unsulfured	.100	Fruit, dried, avg., unsulfured, 100 gm., cooked	.075
Dried, avg., sulfured	.010	Fruit, dried, sulfured, 100 gm. cooked	.007
		Salad greens, 100 gm. svg., raw.	.060

* Figures from U. S. Dept. Agriculture Misc. Pub. No. 572, 1945.

† Deductions have been made for average losses of vitamin B_1 in cooked foods as follows: meats, 40% loss in roasting, 30% in broiling, 15% in frying; vegetables, 25% loss in boiling. There is only 10–15% loss of B_1 in baking bread and no significant loss in cooking cereals in a double boiler. Prolonged cooking, as of dried legumes, causes higher losses; canned vegetables lose much of their B_1 content in the canning liquor that is discarded.

struction, but toasting may cause a further 12–20 per cent loss, depending upon the time and degree of heating. Munsell[16] has stated that, for most foods, there is little actual destruction of thiamine in cooking processes that involve heating at 100° C. (boiling point of water) for not longer than one hour; but losses by solution in the cooking water must be taken into account. In preservation of fruits and vegetables, losses are least in quick-freezing and largest in drying (especially of sulfured fruits). Much of the loss in canning is by solution in the canning liquor, if this is discarded; 30–50 per cent of the vitamin may be dissolved in this fluid.

In Table XVII on p. 239, are given average values for the **thiamine content of foods**—per 100 GRAMS of the **uncooked** foods (second column) and per AVERAGE SERVING of the **cooked** food (fourth column), or raw in case of such foods as are eaten in that state.

In Table XVII, AVERAGE values for the **thiamine content of uncooked foods** are given. It should be remembered that the vitamin B_1 value of individual foods will vary considerably, also that it would take a very large quantity of fruits and vegetables (with thiamine content of less than 0.1 milligrams per 100 grams, or 1 part per million) to furnish a daily allow-

[16] Munsell, H. E., p. 226, in The Vitamins, a symposium pub. by A.M.A., 1939.

ance of 1.5 milligrams of thiamine. But foods of even moderate thiamine content may furnish appreciable amounts of this vitamin, provided they are used in quantity and care is taken to conserve their vitamin content in cooking.

PORK, ORGAN MEATS, LEGUMES, NUTS, and WHOLE GRAINS are excellent or good sources of vitamin B_1. Other meats, eggs, milk, potatoes, and leafy vegetables are moderately good sources of this vitamin. Most fruits and vegetables contain thiamine in relatively small amounts, *i. e.*, an average serving of any one of them will provide only 3–7 per cent of the total quantity needed by an adult daily.

Foods Required to Give Standard Allowance. By consulting the table on page 239 it should be easy to check roughly whether one's customary diet is near the optimum or minimum standard for thiamine intake.

The thiamine content of foods is given in milligrams, since recommended allowances are stated in that unit. In other food tables, the student may find the vitamin B_1 given in micrograms (thousandths of a milligram), which may be converted to milligrams by moving the decimal point three places to the left (dividing by 1000), *e. g.*, 100 micrograms equal 0.1 milligram, or vice versa.

In the average American diet, whole-grain or enriched bread and cereals offer almost the only concentrated source of vitamin B_1, for organ meats, legumes, nuts, and usually pork are either eaten infrequently or in relatively small amounts. An otherwise fairly "good" diet—1 serving of meat (other than pork or organs), 1 potato, 2 servings of vegetables (other than legumes or potato), 1 serving salad greens, 2 servings fruit, 1 pint of milk and 1 egg—will furnish about 0.7 mg. thiamine, not much more than half of the recommended allowance for sedentary adults. Four slices of whole wheat or five slices of enriched bread daily would raise the thiamine intake to about 1 mg. and a liberal serving of oatmeal would bring the day's total intake to 1.2 mg.

For this reason, it is best that most of the cereal products taken should be of the whole-grain type. Those who cannot or will not eat whole-grain breads and cereals should use "enriched" bread and "restored" cereals. In low-cost diets, when the amount of meat, eggs, fruit and vegetables is somewhat limited, an even heavier responsibility rests on whole-grain cereal products and legumes to provide the major part of the standard allowance of vitamin B_1.

It will also be evident that occasional use of pork, liver, leafy vegetables, peas, beans, peanut butter and nuts will be needed to insure a thiamine intake of 1.2 to 1.8 mg., although a freer use of dairy products, fruits and vegetables (especially raw ones) will help toward this end. When one sees

how few foods are really rich in this vitamin, even though it is present in most foods, it is easy to understand why many diets provide enough to avoid serious symptoms of deficiency yet are considerably below the allowance recommended for health.

RIBOFLAVIN (VITAMIN B_2)

Between 1920 and 1927 it became increasingly evident, from the results of many experiments, that there must be at least two vitamins associated in yeast, liver, and the outer coats of grains. Severe heating (at 120° C. in autoclave for several hours) completely destroyed the anti-beriberi vitamin (B_1 or thiamine) in yeast, but there remained another vitamin fraction

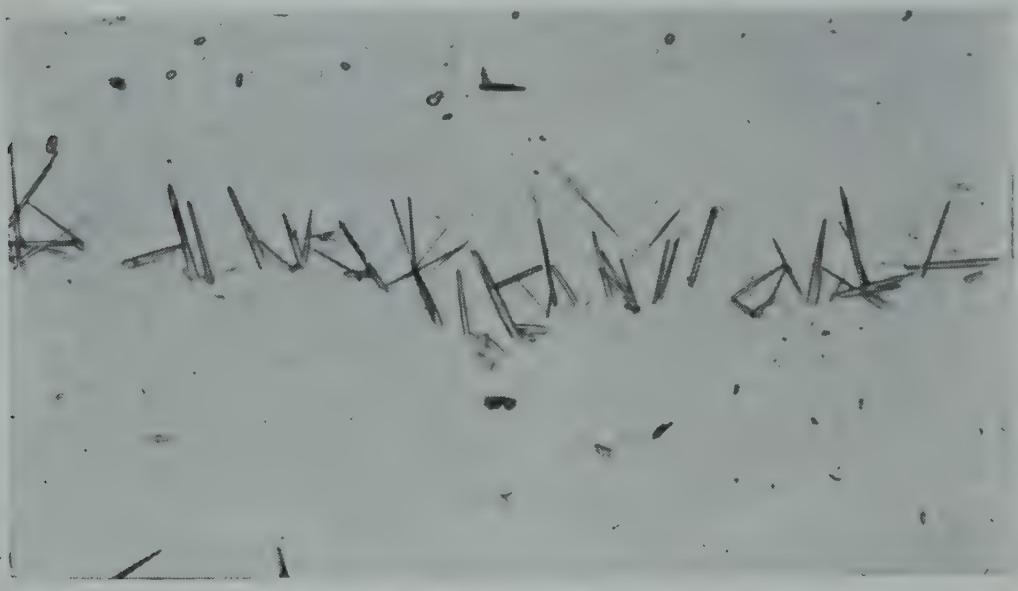


Fig. 35. Microphotograph showing the structure of crystalline riboflavin. (Courtesy of Merck and Company.)

which showed growth-promoting potency. Although this heat-stable fraction is now known to consist of several vitamins, the one first discovered and studied was called **vitamin G or B_2.** It has been isolated in pure crystalline form from yeast, liver, egg white and milk (whey), and proved to be identical chemically from whichever of these sources it was obtained. In 1934–36 its chemical structure was determined and it was first made in the laboratory. This substance was named **riboflavin.**

Riboflavin received its name because it is a compound of ribose (a five-carbon sugar) with a complex colored substance called flavin. The vitamin is an orange-yellow solid, which imparts a greenish-yellow fluorescence to solutions. It is SOLUBLE IN WATER, stable to heating in neutral or acid solutions, but may be destroyed by heating in alkaline solution or by expo-

sure to light. Although riboflavin (B_2) usually occurs along with thiamine (B_1) in foods, certain foods are especially good sources of one of these vitamins and comparatively poor in the other. Egg white is the only food where vitamin B_2 is known to occur with only traces of vitamin B_1.

Riboflavin (free or in combined form) is very widely distributed in both plant and animal tissues. It is formed by all higher plants, chiefly in the green leaves, and the younger parts of the plant contain more than older parts; seeds are rather low in riboflavin, except when sprouting. Most microorganisms also synthesize this vitamin, and bacteria in the intestinal tract may be a considerable but variable source of it for animals. Aside from this undependable source, animals must get riboflavin in their food.

Effects of Deficiency. The vitamin potency of riboflavin was discovered by its effect on **growth.** Experimental animals which receive little or no riboflavin show stunted growth, and when fed graded amounts of this vitamin, they respond with corresponding increases in growth rate. Sherman and Ellis[17] have also shown that animals fed more liberal quantities have better health and vigor, greater ability to bear and suckle offspring, delayed senility and longer life. When the diets of higher riboflavin content were continued for several generations of experimental animals, the benefits to general vitality were more marked in the later generations and at higher levels of vitamin intake up to more than twice the amount of vitamin B_2 required to prevent deficiency symptoms.

This vitamin promotes general health at all ages, because it is the active constituent of several enzymes that are essential to oxidation processes in the various body tissues. In experimental animals long-continued lack of riboflavin leads to SORE MOUTH AND NOSE, falling hair and SCALY SKIN, EYE SYMPTOMS varying in severity from an inflamed condition of the cornea to its complete opacity in cataract, DIGESTIVE DISTURBANCES, NERVOUS LESIONS (severe cases show paralysis of hind legs), poor utilization of food as shown by loss of weight, increasing weakness and death. In man, lack of vitamin B_2 produces less noticeable symptoms. Sebrell,[18] who first produced experimental deficiency of this vitamin in human beings, reported as characteristic symptoms reddened, denuded areas on the lips, with cracks at the angles of the mouth. Later investigations[19] have shown that eye

[17] J. Biol. Chem., v. 104, p. 91, 1934; Proc. Nat'l. Acad. Sci., v. 25, p. 420, 1939; J. Nutrition, v. 25, p. 153, 1943.

[18] Sebrell, W. H., and Butler, R. E., U. S. Public Health Reports, v. 53, p. 2282 and v. 54, p. 2121, 1939.

[19] Kimball, M. S., and Gordon, E. S., J. Biol. Chem., v. 128, 1939; Sydenstricker, Sebrell, *et al.*, J.A.M.A., v. 114, p. 2437, 1940; McCreary, Nichols and Tisdall, J.A.M.A., v. 126, p. 595, 1944.

symptoms occur in man as early evidence of vitamin B_2 lack, low-grade inflammation of the conjunctiva or cornea and a kind of "twilight blindness" somewhat similar to that produced by lack of vitamin A. Others[20] have further defined eye lesions characteristic of riboflavin deficiency and emphasized that these are not specific unless they clear up on giving additional amounts of that substance. Other investigators[21] have shown that



A B

Fig. 36. A, A case of riboflavin deficiency, showing excrescences on the forehead, nose, cheeks, lips and chin and in the folds around nose and mouth. B, The same case after treatment with riboflavin, 15 mg. first two days, 10 mg. for the next two days and 5 mg. daily for one week. (By courtesy of Dr. Bernard Read and Dr. H. C. Hon, Shanghai, and Messrs. Wm. Heinemann, Ltd.)

various symptoms of general debility in man (such as are often seen in pellagra) may be associated with a deficient intake of this vitamin. In both man and animals, most of these symptoms disappear promptly when synthetic riboflavin is given.

Riboflavin in the Body. Riboflavin exists in foods in the free form and combined with other substances. Free riboflavin is readily absorbed from

[20] Mann, I., Am. J. Ophth., v. 28, p. 243, 1945; Spies, T. D., *et al.*, J. Lab. & Clin. Med., v. 30, p. 751, 1945.

[21] Spies, T. D., *et al.*, Am. J. Med. Sci., v. 200, p. 697, 1940; Rosenblum, L. A. and Jolliffe, N., J.A.M.A., v. 117, p. 2245, 1941.

the intestine but the combined form (such as occurs in vegetables and seeds) must be rendered absorbable by cooking. Riboflavin is combined with phosphoric acid in the intestine before absorption and in this form it aids the absorption of sugars and other food substances, hence its presence in the food means better utilization of the diet as a whole.

But the chief function of this vitamin is the rôle it plays in **oxidation-reduction reactions in the tissues.** Riboflavin is contained in a number of different **enzymes,** whose function is to take on hydrogen and pass it on to another substance in the long chain of oxidation-reductions by which hydrogen is finally combined with oxygen to form water. In this way, ribo-

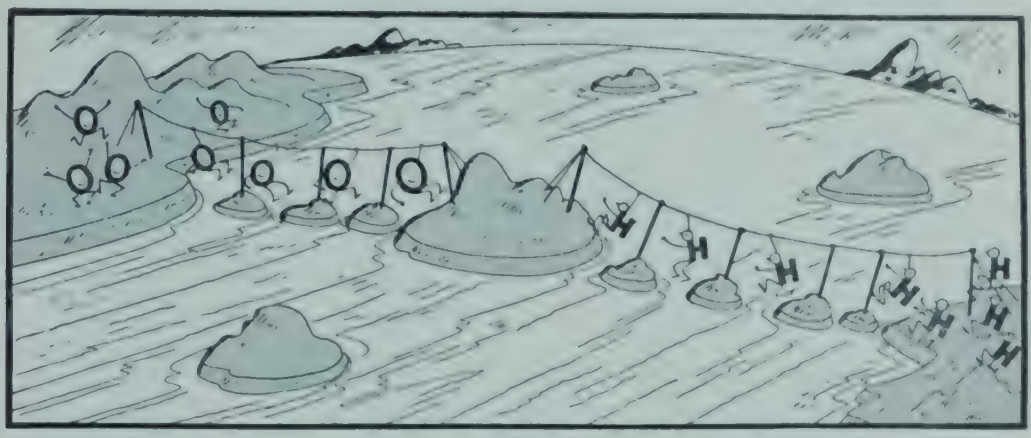


Fig. 37. Diagram to illustrate how enzymes or co-enzymes, which contain vitamins, may act as stepping stones for oxygen or hydrogen atoms in bringing about oxidation-reduction reactions in living tissues. Thiamine, riboflavin and niacin have been shown to form part of enzymes and co-enzymes that function in this manner. The hydrogen and oxygen atoms, separated by an otherwise formidable barrier, are enabled by the use of stepping-stones (enzymes) and the handrails (co-enzymes) to move towards each other and ultimately unite to form molecules of H_2O. (Kermack, W. O. and Eggleton, P.: The Stuff We're Made Of, Edward Arnold and Co., London.)

flavin-containing enzymes assist in the metabolism of carbohydrate, of amino acids, and probably also of fats. These enzymes are formed in tissue cells and carried in the blood. Perhaps because riboflavin compounds, while functioning as enzymes, are built into muscle and glandular tissues (especially the liver and kidneys), the body is depleted of riboflavin more slowly than of thiamine. Since it is essential to numerous chemical changes in tissues, it is natural that deprivation of this substance causes damage to many different types of tissue, and that liberal intakes of it promote the welfare of the body as a whole.

Attempts to follow the distribution of vitamin B_2 in the body have met with less success than was the case with vitamins B_1 and C, due partly to

difficulties in the methods for its determination. We know that riboflavin is found in almost all tissues and is excreted both in the feces and in the urine. The quantity of this substance in the urine reflects only the level of day-to-day intake, and is not a reliable measure of the stores of it in the body. However, in cases of long-standing deficiency, urinary excretion is abnormally low and more of a test dose is retained in the body (and less is excreted in the urine) than in persons whose intake has been adequate for body needs. Several investigators[22] have recently reported that vitamin B_2 deficiency is fairly common among adults, as well as among infants and children.

Requirements and Standard Allowances. Authorities differ on the quantities of B_2 which they deem essential to health. While people may get along on lower levels of B_2 intake without showing any striking symptoms of deficiency, most nutritionists believe that more liberal allowances of this vitamin are conducive to better health. For adults, the MINIMUM of 1 milligram of riboflavin daily is required, but Sebrell has estimated[23] that as much as 3 milligrams daily may be needed for health. As with vitamin B_1, the amount required will vary somewhat with the body weight, the nature of the diet and the DEGREE OF MUSCULAR ACTIVITY. CHILDREN need liberal allowances of riboflavin to provide for maximum growth and development of healthy tissues. The need for this vitamin is also high in PREGNANCY and LACTATION.

Recommended **daily allowances** for vitamin B_2[24] strike a median between the amounts actually required to avoid nutritional disaster and those advised by some as "optimal" for health, as follows:

	Riboflavin *mg.*
Men, avg. wt.	1.8
Women, avg. wt.	1.5
Children:	
Up to 3 years	0.6–0.9
4 to 9 years	1.2–1.5
10 to 12 years	1.8
13 to 15 years	2.0
16 to 20 years, girls	1.8
16 to 20 years, boys	2.5
Pregnant and lactating women	2.5–3.0

[22] Papers cited in footnote 21, page 244; also Sydenstricker, V. P., *et al.*, Am. J. Pub. Health, v. 31, p. 344, 1941, and Kruse, H. D., *et al.*, Natl. Research Council, Bull. No. 109, 1943.

[23] Sebrell, W. H., *et al.*, U. S. Pub. Health Reports, vol. 56, p. 510, 1941.

[24] Recommended by Food and Nutrition Board, National Research Council, 1948.

Riboflavin in Foods. It will be seen from Table XVIII, below, that LIVER, EGGS, LEAFY VEGETABLES, LEAN MEATS, NUTS, LEGUMES and MILK are the foods that rank highest in their content of this vitamin. Both vitamins B_1 and B_2 are almost universally distributed in foods, *i. e.*, only such

TABLE XVIII. APPROXIMATE RIBOFLAVIN CONTENT OF TYPICAL FOODS
(Per 100 Grams of Raw Food)

	Riboflavin		Riboflavin
	milligrams		*milligrams*
Liver	2.80	Whole grains	.14
Cheese, Am., cheddar	.50	Bread, whole wheat or enriched	.15
Eggs	.34	Dried fruits, avg.	.70
Leafy vegetables, avg.	.22	Vegetables (other than leafy and legumes), avg.	.11
Nuts, avg.	.24	Fresh fruits, avg.	.04
Meats, lean muscle	.18		
Legumes, dried	.26		
fresh	.16		
Milk	.17		

foods as pure sugars and fats are entirely lacking in them. While the B vitamins occur together in foods, B_2 is more plentifully supplied in most foods than B_1 and this is notably true of organ meats, leafy vegetables, eggs and milk. Milk carries about four times as much riboflavin (B_2) as thiamine (B_1). On the other hand, the whole-grain cereals, which are one of our richest sources of vitamin B_1, have only a moderate content of B_2. Legumes, nuts, and muscle meats are good sources of both B_1 and B_2. Pork, which has five to seven times the thiamine content of other meats, does not differ from other meats in riboflavin content. Vegetables, other than leafy ones and legumes, and fruits contribute lesser but appreciable amounts of riboflavin in the diet.

Fortunately, this vitamin is sufficiently stable on heating so that little of it is destroyed in ordinary cooking processes, though some may be lost by solution in water in which foods are cooked or canned. Average losses of riboflavin in cooking are 15–20 per cent in meats, 10–20 per cent in vegetables, and 10 per cent in baking bread.

Because of the importance of milk as a dietary source of this vitamin, the possible destruction of riboflavin on exposure of milk to light has been emphasized. Exposure to ordinary daylight may cause considerable losses,[25]

[25] Williams, R. J., and Cheldelin, V. H., Science, v. 96, p. 22, 1942.

but a bottle of milk left standing on the doorstep in direct sunlight may lose 50–70 per cent of its riboflavin potency in two hours time.[26] Losses by exposure to sunlight are high in comparison with only 5–15 per cent destruction of riboflavin in pasteurization of milk or irradiation with ultraviolet light.[27] Caution: take in your milk promptly from the doorstep and keep it in the refrigerator or other dark place.

Foods Required to Furnish Daily Quota. A pint of milk will provide almost half the daily allowance of vitamin B_2; children who take a quart of milk each day will be fairly certain of getting plenty of this vitamin. The following group of foods, as basis of the daily diet, will provide approximately **2 milligrams of riboflavin.**

Milk, 1 pint	1 serving leafy vegetable
Meat, $3\frac{1}{2}$ oz.	2 servings other vegetables
1 egg	2 servings fruit
4 slices whole wheat bread	

It might seem that there should be no difficulty in getting enough of this vitamin but, since authorities now recommend larger allowances of vitamin B_2 than formerly, there is doubt whether many diets furnish the OPTIMUM amounts. Many persons do not use milk, eggs, leafy vegetables and legumes in liberal quantities, and without a quart of milk daily it would be difficult to plan diets that would provide the high levels of 2.5 to 3.0 milligrams of riboflavin which are considered beneficial to health, especially for pregnant and lactating women, adolescent boys and working men.

NIACIN (NICOTINIC ACID)

It was not until 1937–38 that this substance was established as a member of the group of B vitamins and was identified as the long-sought "**pellagra-preventing factor.**" Nearly twenty years earlier Goldberger had shown that pellagra was due to faulty diet and later that it was presumably caused by lack of some vitamin, since its symptoms could be relieved by giving liver, yeast, meats, and other foods rich in B-complex vitamins.[28] This disease appeared in Europe in the difficult times that followed the Napoleonic wars and in mill villages in southern parts of the United States about 1907. Cases increased in number so rapidly as to be of great concern to public health authorities, who were for a time divided as to whether it was due to poor sanitation or diet. Even after Goldberger's experiments

[26] Ziegler, J. A., J. Am. Chem. Soc., v. 66, p. 1039, 1944.

[27] Ziegler and Keevil, J. Biol. Chem., v. 155, p. 605, 1944.

[28] Goldberger, J., *et al.*, U. S. Public Health Reports, vols. 33, 35, 41, 43, and 45, 1918, 1920, 1926, 1928 and 1930.

established that pellagra must be considered a dietary deficiency disease, the exact nature of the causative factor remained a mystery until Elvehjem (1937)[29] showed that black tongue, an analogous disease in dogs, could be cured by giving NICOTINIC ACID. Administration of this substance or a related compound, NICOTINIC ACID AMIDE, was soon shown to cure most of the characteristic symptoms of pellagra in humans.[30]

These substances were found to be normal constituents of living cells and to be present in foods, especially in liver, muscle meats, wheat germ, legumes and leafy vegetables. The simpler names, **niacin** and **niacinamide,** have been adopted by the American Medical Association and the Institute of Nutrition, with the idea of avoiding any possible implication that these "food hormones" are related in nature to nicotine, the alkaloid in tobacco. Both have been obtained in pure, crystalline form from foods and tissues, and have also been synthesized in the laboratory. They are fairly simple organic substances (niacin is a nitrogen containing acid and niacinamide is a basic salt of this acid), SOLUBLE IN WATER, and STABLE ON HEATING.

The Pellagra Problem. Many poor "share croppers" and mill hands in the southern states live almost exclusively on corn meal and grits, soda biscuits, corn sirup or molasses, and fatty salt pork—foods that are deficient in several vitamins and minerals. When pellagra develops on such diets, although it is due primarily to the lack of niacin, it is complicated by lack of other vitamins, especially by lack of the other B-complex vitamins, thiamine and riboflavin. In such cases, niacinamide is given to relieve the chief pellagra symptoms, but full health will be restored only by a diet rich in ALL the B-complex vitamins and possibly other dietary factors lacking in the original diet. Pellagra is now considered to be a complex dietary deficiency, many of whose symptoms are due to lack of niacin or niacinamide.

Pellagra can be prevented and milder cases can be cured by change to a diet that is adequate in all respects, especially as to niacin and other B vitamins. Lean meats, milk and eggs, canned salmon, peanuts, peas, and green leafy vegetables have been shown to be good foods for preventing pellagra.[31] Hence, the campaign to stamp out this disease has centered on urging the poorer families in the South to make gardens about their

[29] Elvehjem, C. A., *et al.*, J. Am. Chem. Soc., v. 59, p. 1767, 1937; J. Biol. Chem., v. 123, p. 137, 1938.

[30] Fouts, Helmer, Lepkowsky, and Jukes, Proc. Soc. Exp. Biol. & Med., v. 37, p. 405, 1937; Smith, Ruffin, and Smith, J.A.M.A., v. 109, p. 2054, 1937; Spies, T. D., *et al.*, J.A.M.A., v. 110, p. 622 and v. 111, p. 584, 1938; Ann. Int. Med., v. 12, p. 1830, 1939.

[31] Sandels and Grady, Arch. Int. Med., v. 50, p. 362, 1932; Stiebeling and Munsell, U. S. Dept. Agriculture, Tech. Bull. No. 333, 1932.

homes, to keep a cow and some chickens, and to spend some of their income for foods known to be rich in B-vitamins. Public health authorities in some states supply free dried yeast, which has a higher content of niacin and other B-vitamins than any food. A recent dietary survey[32] of two adjacent communities in the Kentucky mountains, one of which had high incidence of pellagra and the other almost none, attributed the freedom from this disease in one district to promotion of gardens and education as to better choice of foods. DeKleine[33] calls attention to the decrease in mortality from pellagra in southern states from 22.4 to 5.1 per 100,000 between 1929 and 1940, and deaths from this cause have decreased sharply since the institution of niacin treatment in 1938. But eradication of pellagra involves both education in change of food habits and increased income levels to make possible the purchase of needed foods, so that it is bound to be slow. In the meantime, public institutions are no longer crowded



Fig. 38. Pellagra in a child, showing typical red rash on the face and hands. (Courtesy of Dr. John A. McIntosh.)

with pitiful and hopeless cases of this disease since the discovery of the benefits of niacin treatment.

The most striking and characteristic **symptoms of pellagra** are a reddish skin rash (especially on face, hands, and feet when exposed to light, see Fig. 38) which later makes the skin dark and rough (the word "pellagra" means rough skin), sore mouth and tongue, inflamed membranes in the digestive tract, with bloody diarrhea in the later stages, and also, in advanced cases, distressing nervous and mental disturbances. Physicians sometimes refer to pellagra symptoms as "the three D's—dermatitis, diarrhea, and depression," and consider that when either the digestive or the nervous disturbances occur along with the characteristic skin lesions a diagnosis of pellagra is justified. Less acute symptoms of niacin deficiency

[32] Kooser, J. H., and Blankenhorn, M. A., J.A.M.A., v. 116, p. 912, 1941.
[33] DeKleine, W., South. M. J., v. 35, p. 992, 1942.

may be hard to recognize. Kruse[34] has described changes in the tongue, which he believes are one of the earliest signs of niacin lack and may be used to detect it. LATENT or mild pellagra has been reported in infants and children,[35] in which the usual pellagra symptoms were lacking but weakness and failure to grow properly responded favorably to treatment with niacinamide. Hence we see that this vitamin is necessary for GROWTH and for HEALTH OF TISSUES, and it has also been shown to promote appetite, proper functioning of the digestive tract and good utilization of foodstuffs in the body.

Niacin in the Body. The chief function of this vitamin in the body is to form the active portion of CO-ENZYMES THAT PLAY AN ESSENTIAL ROLE IN TISSUE OXIDATIONS, and it thus promotes the health of tissue cells.



A B

Fig. 39. Cure of pellagrous lesions on hands of an adult by diet rich in B vitamins, especially niacin. *A*, hands of pellagra patient; *B*, same patient after two weeks of corrective diet. (Spies: Rehabilitation Through Better Nutrition, 1947, W. B. Saunders Co.)

Niacinamide, in both free and combined form, is carried in the blood and found in all tissues, but most richly in liver, kidney, heart, brain, and muscles. It is built into two co-enzymes, which by virtue of their ability to alternately take on or give off hydrogen, act as "hydrogen carriers" (in conjunction with riboflavin-containing enzymes) in passing along this element from fuel materials (chiefly carbohydrate) to its eventual union with oxygen. Lack of niacin to form these enzymes in sufficient quantities will handicap vital chemical processes and may result in injury to tissues throughout the body.

[34] Kruse, H. D., Milbank Memorial Fund Quart., v. 20, p. 262, 1942.

[35] Spies, T. D., *et al.*, "Pellagra in Infancy and Childhood," J.A.M.A., v. 113, p. 1481, 1939.

There is little storage of this vitamin in the body and the end-products of its metabolism are excreted in the urine. Chemical tests on blood and urine to detect early deficiencies have not been very successful, though pellagra patients have been shown to excrete less niacin derivatives in the urine than normal persons. Those whose habitual diet is low in niacin also excrete less of a test dose of this substance than those whose diet has furnished plenty of it.

Niacin and its compounds are found in the feces in varying amounts, some of which are doubtless unabsorbed portions of the food intake but some of which may have been formed by intestinal bacteria. We know that many bacteria can synthesize this and other B vitamins; in fact, the feces have been shown in some instances to contain more of certain B vitamins than were present in the food. But this is too variable and uncertain a source of niacin to count on, so that it is wise to make sure that the daily diet furnishes plenty of this vitamin.

Niacin in Foods. Although neither the biological assay nor chemical methods for determination of nicotinic acid and its amide are entirely satisfactory as yet, the data given in Table XIX are in general use[36] and of sufficient interest to justify their inclusion here.

TABLE XIX. APPROXIMATE NIACIN CONTENT OF TYPICAL FOODS
(Per 100 Grams of Raw Food)

	Niacin.		Niacin.
	milligrams		*milligrams*
Liver	16.1	Dried fruits, avg.	2.7
Peanuts (peanut butter)	16.2	Nuts (not peanuts), avg.	1.9
Tuna fish, canned	10.6	Peas, dried	3.0
Heart	6.8	Beans, dried	2.1
Salmon, canned	6.5	Green peas, fresh	2.1
Meats, lean muscle, avg.	5.1	Lima beans, fresh	.9
Whole wheat	4.6	Corn, sweet, fresh	1.4
Bread, whole wheat	3.5	Leafy vegetables, avg.	.65
enriched white	2.2	Other vegetables, avg.	.5
Corn meal, whole, yellow	2.1	Fresh fruits, avg.	.38
Rice, white	1.4	Cheese, Am., cheddar	.2
Oatmeal, dry	1.1	Eggs, whole, fresh	.1
Corn meal, degerminated	.9	Milk, whole, fresh	.1

It should be noted that most of the foods that are good sources of thiamine and riboflavin are also high in niacin content (liver, lean meats,

[36] Figures are from Tables of Food Composition, U. S. Dept. Agriculture, Misc. Pub. No. 572, 1945.

whole grains, nuts and legumes). However, eggs, milk and cheese are relatively low in niacin, while leafy vegetables are not much higher than other vegetables. As with vitamins B_1 and B_2, foods that are not rich in this vitamin may yet furnish considerable amounts if they are eaten in quantity. Niacin is heat stable, so that little of it is lost in cookery except by solution in cooking water that is discarded. Meats and vegetables are said to average only 15 per cent destruction of niacin in cooking, though up to 50 per cent may be in the cooking water.

Niacin is present in most foods in much larger amounts than is thiamine or riboflavin. For instance, lean muscle meats carry nearly 40 times as much niacin as thiamine and 30 times as much niacin as riboflavin. The recommended allowance for daily intake of niacin is about ten times greater than that for vitamins B_1 and B_2.

But the actual amount of niacin in a given food may not be the only factor to be taken into consideration. Milk, eggs, and leafy vegetables exert a greater influence in preventing pellagra than would be expected from their low niacin content, while the inclusion of large quantities of corn in the diet seems to predispose toward the development of this disease. Scientists have long been puzzled by the frequency with which symptoms of niacin deficiency (pellagra) developed among corn-eating peoples. Recently it has been shown[37] that the amount of a certain amino acid, tryptophane, in the diet may be the determining factor in whether niacin deficiency develops or not. Corn protein is very low in tryptophane; animals showed signs of niacin lack on diets containing large amounts of corn, or other diets low in tryptophane; symptoms of niacin deficiency were prevented by adding small quantities of this amino acid to the diet. It is clear that tryptophane exerts a sparing action on niacin, though it is not yet known whether it does this because it gives rise to niacin in the body, favors its production by intestinal bacteria, or otherwise reduces the need for this vitamin in the diet.

Requirement and Recommended Allowance. It should be evident from the above discussion that the actual REQUIREMENT for niacin will vary with the nature of the diet. It also varies according to body weight and degree of muscular activity. Recent careful work places the niacin requirement at 0.15 mg. per kg. body weight, or 10.5 mg. daily for a 70 kg. (154 lb.) man. Aykroyd[38] found that 5 mg. daily seems to be adequate for rice-eating adults, whereas corn-eaters may develop pellagra on somewhat

[37] Wintrobe, M. M., *et al.*, J. Nutrition, v. 30, p. 395, 1945; Krehl, Elvehjem, *et al.*, J. Nutrition, v. 31, p. 85, 1946.

[38] Aykroyd, W. R., and Swaminatham, M., Indian J. M. Research, v. 27, p. 667, 1940.

higher intakes. The OPTIMUM or RECOMMENDED ALLOWANCE is, of course, considerably higher. The National Research Council recommends (1948) ten times as much niacin as thiamine, *i. e.*, a sedentary man or moderately active woman should get in the food daily 1.2 mg. thiamine and 12 mg. niacin. Larger and more active adults, and pregnant or lactating women, may profit by intakes 15-18 mg. daily, while the needs of growing children are higher in proportion to weight than those of adults.

The average American diet provides plenty of niacin to prevent pellagra, but probably often less than the optimum amounts recommended above. Even in northern states, physicians frequently see border-line cases of niacin deficiency, especially among chronic alcoholics and persons who have been living on limited diets (such as those for gastric ulcer or colitis). With relatively large amounts of niacin in numerous foods, it should not be difficult to secure enough of this vitamin on any reasonably well-balanced diet, unless there is excessive loss of B vitamins in cooking water, by prolonged stewing, or use of soda in cooking. Government authorities have advised that any ONE of the following items in the diet daily will suffice to prevent pellagra:

A quart of fresh milk (or its equivalent of evaporated or dried milk);
One-third to one-half pound of lean meat, canned salmon, peanut meal, or wheat germ;
One pound of fresh or canned collards, kale, turnip greens or green peas.

Using fractional combinations of these foods, it will be seen that pellagra protection would be afforded by one pint of milk and three to four ounces of lean meat daily. Free use of whole grains, legumes, leafy and other vegetables, and occasional use of organ meats should raise the daily intake of niacin to the recommended levels.

OTHER VITAMINS OF THE B-COMPLEX

Pyridoxine or Vitamin B_6 was isolated in 1938 and synthesized in the following year. Since it contains the same chemical nucleus (pyridine) as nicotinic acid, it seemed probable that it also functioned in some enzyme system concerned in tissue metabolism. It has now been shown to be the active group in co-enzymes essential to certain steps in the metabolism of amino acids. Hence this vitamin plays an important role in protein metabolism, and it may also be involved in fat metabolism.

Pyridoxine was first recognized as a factor necessary for GROWTH and for PREVENTION OF a particular type of SKIN DISORDER in rats, similar to that produced by lack of essential fatty acids. Dogs and pigs on B_6-deficient diets develop a certain kind of anemia, as well as epileptic-like con-

vulsions. It is also required by pigeons and chickens. Lack of this vitamin is accompanied by decreased consumption of and POOR UTILIZATION OF FOOD.

We know little of the value of pyridoxine in human nutrition. Since it and or two important derivatives that have similar vitamin activity (pyridoxal and pyridoxamine) are widely distributed in foods, occur in blood, tissues and urine of man, and are needed in the diet of all other animals so far investigated, it is extremely probable that this vitamin is required by man. Nevertheless, attempts to treat conditions in humans, which are similar to symptoms of pyridoxine deficiency in animals, by administration of this vitamin have been disappointing and inconclusive. Even the claim that doses of it were of benefit in cases of pellagra, which represents deficiency of numerous B-complex factors, has been challenged.

The occurrence of vitamin B_6 in foods follows the general distribution of other vitamins of the B-complex. In milling of patent flour, half of the pyridoxine content of wheat is lost. Vitamins B_1, B_2 and B_6 are concentrated in the germ portion of the wheat to a much greater extent than are niacin and pantothenic acid.[39] The roasting or stewing of meat causes 20–50 per cent loss in its pyridoxine content.[40]

Pantothenic acid is another B-complex vitamin that was discovered as a factor which promoted GROWTH of yeast and green plants, and also prevented a SKIN DISEASE in chicks. In 1940 its chemical structure was established and it was made in the laboratory. Because of its occurrence in all plants and animals, it was given the name of pantothenic acid, which indicates that it is found everywhere. It is a growth-promoting substance for higher animals (pigs, dogs) and is probably also needed by man. A deficiency of this vitamin affects many tissues, causing bald spots, gray hair and skin disorders (in rats), ulcers in the intestinal tract (dogs), a "goose-stepping" gait (pigs), pathologic changes in the central nervous system and DEGENERATION OF ADRENAL GLANDS (in several species). In man, doses of pantothenic acid have been claimed to relieve symptoms of peripheral neuritis and alcoholic psychosis, which did not respond to treatment with other pure B-complex vitamins. However, evidence is fairly decisive that the use of this vitamin in large doses over long periods will NOT restore color to gray hair in human beings.

The mode of action of pantothenic acid is not yet clear, but its function seems to be associated with that of riboflavin, since doses of either vitamin

[39] Tepley, Strong, and Elvehjem, J. Nutrition, v. 24, p. 167, 1942.

[40] Henderson, L. M., Waisman, H. A., and Elvehjem, C. A., J. Nutrition, v. 21, p. 589, 1941.

cause increases of the other in the blood. There are doubtless interrelations between this vitamin and others of the B-complex, *e. g.*, pyridoxine.

Biotin was first recognized as a growth requisite for bacteria and yeasts, but is now known to be a dietary essential for many species of animals, including man. Its chemical structure was determined and its synthesis in the laboratory announced by du Vigneaud in 1942. It is found in almost all plant and animal tissues, concentrated particularly in young, rapidly growing cells or organisms. Although its exact rôle in metabolism is not yet known, it seems probable that this substance acts through one or more enzyme systems to produce its effects of stimulating growth and respiration of cells. Since biotin is present in most foods and needed in exceedingly small amounts, the natural occurrence of biotin deficiency in man is unlikely. Such deficiency has been experimentally induced in humans by use of a diet low in biotin supplemented by large amounts of dried egg white. Egg white is known to contain a protein substance, avidin, which combines with biotin so as to render the latter unabsorbable from the intestinal tract. This artificially produced biotin deficiency resulted in man in pathological changes in the skin and tongue, loss of appetite, heart symptoms, and intense depression with hallucinations. Injections of biotin brought marked improvement of symptoms in 3–4 days. The rôle of biotin in reproduction and in tumor development is also being investigated, as it seems to be present in greater amounts in rapidly growing tissues such as those of the fetus or tumor.

Folic acid is another one of the B vitamins that has sprung into prominence in the last few years. First discovered in 1941 in spinach and alfalfa as a growth promoting factor for certain microorganisms (its name comes from its occurrence in foliage), it was later shown to be closely related to, if not identical with, factors whose lack caused anemia in monkeys and chicks and which were also needed for growth of animals. Yeast and liver concentrates were rich in the same or similar substances as those found in green leaves. The lines of research culminated in 1945 in the isolation and synthesis of folic acid by a group of chemists at the Lederle Laboratories. It is a rather complex compound formed by linkage of a fluorescent pigment (pterin) with para-aminobenzoic acid and another amino acid (glutamic acid). In plant and animal tissues it occurs widely both in free and bound forms, the latter of which can be utilized only by animals that have digestive enzymes to free it. Immediately after its synthesis, folic acid was tried out on patients suffering with anemia with strikingly beneficial effects in at least five forms of "macrocytic" anemia, including pernicious anemia. In macrocytic anemia the red blood cells are fewer in number and larger

in size than normal; giving folic acid by mouth or by injections, resulted in formation and development to maturity of very many new red blood cells. Anemias due to lack of iron and certain other causes are not relieved by folic acid. Treatment with liver extract (which contains folic acid plus other substances) is preferred in certain types of anemia, but the demonstration of the part played by this vitamin in blood formation is a great step forward.

Several other interesting members of the B-complex have been demonstrated and identified chemically—**choline, inositol,** and **para-aminobenzoic acid.** Although the vitamin activity of these vitamins has been demonstrated chiefly by experiments on microorganisms, plants, or lower animals, they are known to play essential rôles in metabolism. Choline and inositol are apparently concerned in metabolism of fats. Para-aminobenzoic acid plays an interesting rôle in that it neutralizes the effect of sulfa drugs, presumably by competing for position in some enzyme system essential to growth of bacteria. Since the discovery that para-aminobenzoic acid is an essential constituent of folic acid, its function as a separate vitamin entity has been questioned. Little is known as yet as to their importance in human nutrition.

How to Get B-complex Vitamins in the Diet. The number of different vitamins in the B-complex need not distress the elementary student, since they are found together in foods. If the diet furnishes plenty of the important B_1 (thiamine) and B_2 (riboflavin), it is probable that sufficient amounts of the less well-known B vitamins will be provided at the same time. Although present in minor amounts in many foods, the staple foods upon which we depend chiefly for B-complex vitamins are MEATS, MILK, EGGS, LEGUMES and GREEN VEGETABLES, with considerable additions from WHOLE GRAIN BREADS AND CEREALS if these are used. Liver served at least once a week, a few tablespoonfuls daily of wheat germ, bran or crude molasses, or tablets of DRIED brewers' yeast,[41] are inexpensive ways to reinforce the intake of B vitamins for those whose diet consists largely of refined and canned foods. From such natural sources one gets a better BALANCED ration of ALL these B-complex vitamins than by taking individual synthetic vitamins or "enriched" foods to which large quantities of some and none of others may have been added. There is considerable evidence to prove that the relative proportions of nature's mixtures of B vitamins in foods are those best adapted for promoting health.

[41] It has been shown that live yeast cells hang onto their content of B-complex vitamins, so that little of these are available to the body when yeast is eaten in the "raw" state. However, if the yeast cells are killed by boiling or drying, the B vitamins in them are well absorbed from the intestinal tract.

QUESTIONS AND PROBLEMS

1. Enumerate seven vitamins that are known as B-complex vitamins. For each of the following, give its chief use (or uses) in the body and the symptoms that are characteristic results of a deficiency of it in the diet: thiamine, riboflavin, niacin.

2. Either make out a day's menus for what you would consider an attractive diet, or set down your actual food intake for an average day. Specify the amounts of each food consumed. Consult the tables in the preceding chapter and in the Appendix for content of foods in thiamine, riboflavin, and niacin. Calculate the total quantities of these three vitamins which would be provided in the day's diet that you planned or consumed.

3. Look up in the preceding chapter the recommended allowance for each of these three vitamins for a person of your sex, size, and degree of activity. How does the intake of each vitamin in the calculated diet compare with the recommended allowance? What foods fairly rich in these three vitamins might be used to increase the thiamine, riboflavin and niacin content of the diet?

4. From the figures given below, how much liver would be required to add 5 milligrams of niacin ($\frac{1}{3}$ day's allowance for physically active man) to the diet? How much dried brewers' yeast to contribute 1 milligram ($\frac{2}{3}$ daily allowance for sedentary woman) of riboflavin? How much wheat germ to provide 0.5 milligram of thiamine ($\frac{1}{3}$ daily allowance for moderately active man)? Weight for weight, which of these substances is richest in thiamine, in riboflavin, in niacin?

	Weight, *grams.*	Measure.	Thiamine, *mg.*	Riboflavin, *mg.*	Niacin, *mg.*
Liver, beef, fried	80	2 slices, $2\frac{3}{4}$x2x$\frac{3}{16}$ in.	0.184	1.90	10.95
" " "	10		.023	.24	1.37
Yeast, dried, brewers'	10	1 tablespoonful	.969	.54	3.62
Wheat germ	10	1 tablespoonful	.205	.08	.46

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CHAPTER 16

FAT-SOLUBLE VITAMINS

AT FIRST glance it might seem that the problems of fat-soluble vitamins would be simpler than those concerned with water-soluble ones—they are much fewer in number, more stable to heat, and less likely to be lost in the cooking and processing of foods. But other complicating factors appear which are peculiar to this type of vitamin. Among fat-soluble vitamins, vitamin activity is frequently not confined to a single substance, but **several** chemically similar substances will produce a like effect on the body, *i. e.*, all show the same kind of vitamin activity, though perhaps in varying degree. For the sake of simplicity, a letter of the alphabet is used to designate such a GROUP of substances that possess the same vitamin activity, AS IF A SINGLE SUBSTANCE WERE CONCERNED.

In addition, there exist in foods certain **precursors** or **provitamins,** substances which themselves have no vitamin activity but which give rise to fat-soluble vitamins when taken into the body. For vitamin D, a precursor is present in the skin (and tissues just under it) which is converted into vitamin D by action of sunlight, so that this vitamin can be made in the body. Finally, fat-soluble vitamins are **stored in the body,** chiefly in the liver, to a much greater extent than is true of water-soluble ones. Hence previous feeding of them may accumulate a reserve against time of need, deficiency symptoms may be slow in developing, and there is greater difficulty in detecting low-grade shortage of this class of vitamins.

VITAMIN A

The presence of this vitamin in certain fats was first detected by reason of its effect in promoting growth. This discovery was made in 1913, independently by Osborne and Mendel and by McCollum and Davis. Rats fed on purified foodstuffs with lard as the only fat ceased to grow, developed soreness of eyes, and eventually died. With butter fat or ether extract of egg yolk in the diet, they were protected from these ill effects. Although vitamin A was obtained as a pure substance from fish liver oil in 1936 and claims of its synthesis have since been made, we still depend chiefly on

fish liver oils (or extracts made from them) for concentrated sources of this vitamin.

Vitamin A is almost COLORLESS, INSOLUBLE IN WATER, SOLUBLE IN FATS and fat solvents, fairly STABLE TO HEAT, but may be DESTROYED BY OXIDATION at high temperatures or by exposure to ultraviolet light. Fats and oils lose vitamin A content as they become rancid. Two slightly different forms of this vitamin, A_1 and A_2, are known, but the latter occurs only in fresh-water fish and birds that feed on these fish. Vitamin A_1 is found in the livers and body fat of salt-water fish, and in other foods of animal origin, such as liver, milk, butter and egg yolk. Since both have the same physiological effects, we need make no distinction between them.

Animals get their vitamin A either directly or indirectly from plant sources. Fish eat smaller fish or crustaceans which, in turn, have fed on marine plants that contain the precursors of this vitamin. Herbivorous animals eat green plants that carry provitamins A and convert these substances into the vitamin itself in their bodies; carnivorous animals get the vitamin from feeding on plant-eating animals. The cow and hen are useful to man by converting provitamins in plant foods into the vitamin A in milk, butter and eggs. Since some provitamins in the diet escape this conversion, MILK FAT (butter) and EGG YOLK contain a MIXTURE of both vitamin A and its plant precursors, the relative amounts of each depending chiefly upon the food of the animal.

The **provitamins A,** which are found in plants instead of vitamin A, are enough different chemically to have quite a different appearance. They are bright YELLOW or ORANGE YELLOW pigments, which give the color to carrots, sweet potatoes, squash, pumpkin, apricots, yellow peaches and corn. They are also present in all green vegetables, although there their color is masked by that of the green pigment, chlorophyll. As the quantity of these vitamin A precursors roughly parallels that of chlorophyll, being found most richly in thin, green leaves, the chlorophyll may be concerned in their formation. Young, rapidly growing plants or parts of the plant contain more than older plants.

Three of these "percursors" are known as **carotenes** (alpha, beta and gamma) and a fourth is cryptoxanthin. When these substances are taken into the body, they give rise to vitamin A, probably through the action of an enzyme in the liver. Each molecule of beta-carotene is capable of yielding TWO molecules of vitamin A, but the other three provitamins can yield only HALF AS MUCH vitamin A. Of course some of the provitamins in food may escape absorption from the intestine, and one cannot be sure that those that are absorbed will be completely converted to vitamin A. There are dif-

ferences in species and in individuals as to how well they utilize carotenes (varying from 30–70 per cent in man),[1] but it is usually estimated that LESS THAN HALF OF THE CAROTENE intake may be expected to be TRANSFORMED INTO VITAMIN A. Foods that contain carotenes are said to have **vitamin A value,** even though they do not carry this vitamin in a preformed condition.

Effects of Lack. A diet that contains insufficient amounts of vitamin A (or its precursors) to meet the needs of human beings will in time cause STUNTING OF GROWTH, LACK OF ABILITY TO SEE WELL IN DIM LIGHT (night blindness) or more serious eye troubles, and diseased conditions of the SKIN and membranes that line the RESPIRATORY PASSAGES, DIGESTIVE AND GENITOURINARY TRACTS.

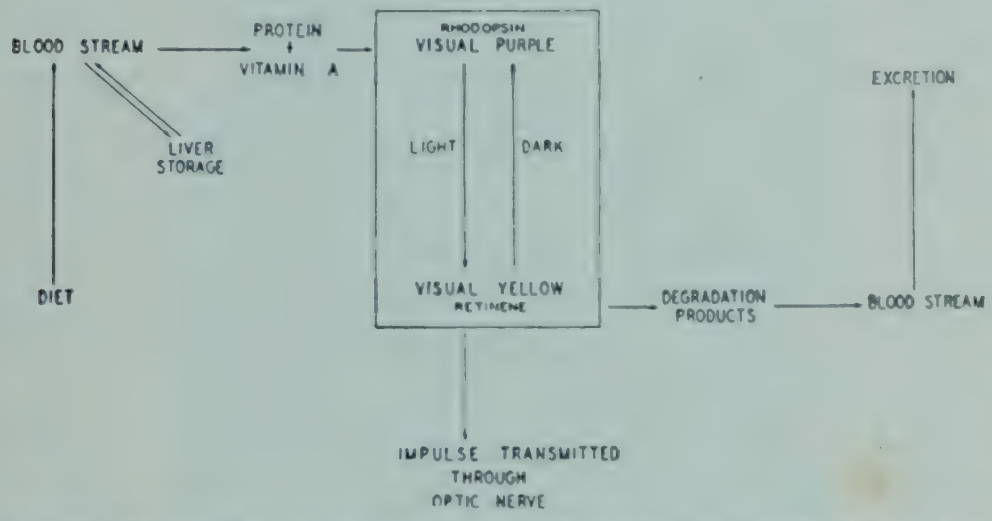


Fig. 40. Diagram of visual cycle, showing why vitamin A from the blood stream is needed to rebuild the pigment, visual purple, in the eye after exposure to light. (Gordon and Sevringhaus, Vitamin Therapy in General Practice. 1940, Yearbook Publishers, Inc.)

The **eye** is one of the first organs to show effects of vitamin A lack, because this vitamin is a CONSTITUENT OF PIGMENT IN THE RETINA. When light falls on the retina this pigment, called visual purple, is bleached to another known as visual yellow and, as a result of this change, images are transmitted to the brain through the optic nerve. In the dark, the vitamin A-containing visual purple is rebuilt, but there is always some loss of degradation products (see Fig. 40), which necessitates new supplies of vitamin A brought by the blood. If vitamin A is at a low level in the blood, normal vision will be restored slowly and "dark adaptation" of the eyes will be

[1] With, T. K., ABSORPTION, METABOLISM AND STORAGE OF VITAMIN A AND CAROTENE, Chap. VII, published by Humphrey Milford, Oxford, Eng., 1940.

faulty. Tests for dark adaptation seemed to offer a way of detecting early vitamin A deficiency, but experience has shown that this function is influenced by too many other factors to be an infallible index as to whether the diet is adequate in vitamin A. Moreover, stores of vitamin A in the liver can be drawn upon to replenish the vitamin A in the blood stream, so that low level of this vitamin in blood may not appear until late in a deficiency. But lack of vitamin A is ONE of the causes of NIGHT BLINDNESS and a good many cases do respond favorably to extra doses of this vitamin. It has been shown to be prevalent in regions where the diet is low in vitamin A and occurs fairly frequently among supposedly well-fed Americans. Automobile accidents in night driving may sometimes result from this cause, especially if the driver sees poorly after exposure to the bright headlights of on-coming cars.

An even more delicate test for detecting deficiency of vitamin A by eye examination has recently been suggested.[2] This depends upon examination of the conjunctiva, the membrane that lines the eyelids and covers the front of the eyeball, with a biomicroscope. It is claimed that one of the first symptoms of vitamin A lack is tiny lumps or puckers (due to piling up of damaged epithelial cells) which may be seen on the conjunctiva even preceding failure of dark adaptation, and which subside on giving vitamin A (or carotene) While this test may be of value in determining early stages or milder degrees of vitamin A deficiency, there is insufficient evidence as yet to appraise its usefulness.

One of the chief functions of vitamin A is to maintain the health of **epithelial tissues,** namely the skin and membranes that line all passages which open to the exterior of the body. When deprived of an adequate supply of vitamin A, these tissues undergo changes that lead to a peculiar type of horny degeneration called keratinization. Damage to the mucous membranes that line the mouth, throat, nose and respiratory passages is one of the earlier effects of vitamin A lack. In addition to general deterioration of the cells, these membranes lack their normal secretions and there is loss of the little filaments called cilia, which, by constant movement, aid in keeping the membrane surface clean. As bacteria have easy access to these parts, susceptibility to COLDS, SINUS TROUBLE, SORE THROAT, ABSCESSES IN EARS, MOUTH OR SALIVARY GLANDS are common manifestations of insufficient vitamin A in the diet. Similar damage to membranes that line the alimentary tract may allow bacteria to penetrate into the stomach or intestinal wall, whence they may be carried in the bloodstream to other parts of the body.

[2] Kruse, H. D., Pub. Health Report, v. 56, p. 1301, 1941.

The frequency of infections of various kinds (especially of the respiratory tract) in severe vitamin A deficiency has encouraged the use of concentrated preparations of this vitamin for the prevention and treatment of colds and other similar infections. Statistics as to whether extra vitamin A raises resistance to infections is conflicting but mostly on the negative side. Probably vitamin A shares with other vitamins in promoting health of tissues and is "anti-infective" chiefly in the sense that it helps to keep



Fig. 41. Xerophthalmia in a child due to malnutrition during war. The disease was cured by administration of vitamin A, in the form of butter and cod liver oil, but had already progressed so far that the sight of the left eye was destroyed by corneal ulcers and the right eye was also somewhat damaged. (Courtesy of Dr. Bloch of Copenhagen.)

healthy the lining membranes that are the "first line of defense" to prevent entrance of bacteria into the body. If there has been previous deficiency of this vitamin in the diet, extra doses of it will be helpful in rebuilding stores of it in the liver and restoring damaged epithelial tissues to health.

More prolonged lack of vitamin A results in dry and scaly skin, with plugs of horny material about the hair follicles, and in the eye disease known as **xerophthalmia**. In the latter disease, the secretion of tears is stopped, the eyes are sensitive to light, the lids become swollen and sticky

with pus, bacteria may invade the eye itself and cause ulcers of the cornea, which lead to blindness if the disease is not arrested (see Figs. 41 and 42, pp. 265 and 266). Xerophthalmia is most often seen in infants or undernourished children, and may be prevented by including in the diet some



Fig. 42. Xerophthalmia in a puppy due to feeding a diet deficient in vitamin A. Note the swollen lids and sticky discharge from the eyes. Full recovery after administration of vitamin A is shown in the lower picture. (Courtesy of Doctors Steenbock, Nelson and Hatt.)

good source of vitamin A, such as cod liver oil, butter, whole milk, or egg yolk.

Vitamin A is also essential for proper formation and maintenance of tooth enamel, for health of membranes that line the bladder, urinary pas-

sages, uterus, vagina, etc., and for the welfare of sex glands. Some investigators believe that lack of this vitamin is associated with a tendency toward formation of kidney or bladder stones. Others have found nervous lesions to develop in animals on vitamin A deficient diets; it is stated that the bony structure ceases to grow (due to vitamin A lack) before growth of nervous tissue is inhibited, and that the resultant crowding of nerves in the bony cavities of the skull and spinal column is the cause of nervous lesions. It is certain that this vitamin is needed in considerable amounts to insure optimum **growth** (Fig. 43, p. 267) and successful **reproduction.**

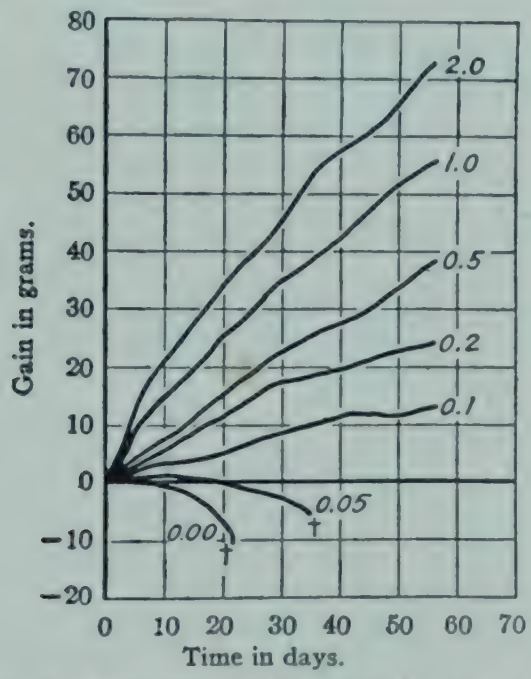


Fig. 43. Curves showing differences in rate of growth (in rats) due to differences in intake of vitamin A. Figures at the end of each curve indicate the amount of tomato (in grams) fed daily as the sole source of vitamin A. (Courtesy of Drs. H. C. Sherman and H. E. Munsell and Jour. of the Am. Chemical Society.)

Vitamin A in the Body. Although it is not yet known how vitamin A acts to promote the health of tissues, chemical and physical methods for detecting and measuring it in blood and tissues have enabled us to follow its course in the body. Preformed vitamin A in foods of animal origin is normally very completely absorbed, but any factor that lowers fat absorption will also affect UTILIZATION of fat-soluble vitamins unfavorably. Both carotene and vitamin A in butter are nearly 100 per cent absorbed,[3] but absorption of the provitamins A (carotenoid pigments) from fibrous vegetable material is less efficiently accomplished. Carotenes in green peas are

[3] Kreula, M., and Virtanen, A. I., Upsala Lakareforen. Förh., v. 45, p. 355, 1939.

somewhat better utilized than those in spinach,[4] but both these vegetables and carrots have much lower vitamin A value than equivalent quantities of vitamin A taken in cod liver oil. Presence of MINERAL OIL in the intestine interferes alike with absorption of vitamin A, carotenes and other fat-soluble vitamins (they dissolve in the oil, which is nonabsorbable).[5] Hence mineral oil should not be incorporated in foods (as in salad dressings) and, if used for a laxative, it should be taken only in small amounts and at a period remote from mealtimes (*e. g.*, just before going to bed at night). Even under favorable circumstances, a considerable amount of food carotenes will escape absorption and be excreted in the feces.

Both vitamin A and carotene are CARRIED IN THE BLOOD. The **liver** takes up any excess of these substances, converts carotenes to vitamin A, and **stores reserves of this vitamin** which can be released into the blood and carried to tissues later as needed. The level of vitamin A in the blood is thus kept fairly constant and would not be affected by vitamin A-poor diet until the body reserves (90–95 per cent of which are in the liver) were nearly exhausted. How much vitamin A has been tucked away in the liver depends, of course, on whether the habitual diet has been rich or poor in vitamin A and its precursors. Since reserve stores of vitamin A exist but are variable in amount in different individuals, it is natural that SYMPTOMS DUE TO VITAMIN A LACK SHOULD DEVELOP RATHER SLOWLY and that the time interval before deficiency symptoms appear will differ according to the extent of body stores available to draw upon in time of need.

Irrespective of liver reserves, some persons develop the eye symptoms characteristic of vitamin A lack much more readily than others,[6] and it is doubtful whether a LOW LEVEL OF VITAMIN A IN THE BLOOD can be shown to occur regularly in cases of poor dark adaptation or night blindness, though it is frequently present. In xerophthalmia, which develops after longer deficiency, low blood vitamin A is usually present.[7] Although in general there is a rough parallel between levels of vitamin A in the diet and in the blood, exceptions occur frequently enough to make values for vitamin A in blood an uncertain index of the nutritional level.[8]

The technic of following the blood level after administering a test dose

[4] Booher, L. E., and Callison, E. C., J. Nutrition, v. 18, p. 459, 1939.

[5] Rountree, J. I., J. Nutrition, v. 3, p. 345, 1931; Dutcher, R. A., *et al.*, J. Nutrition, v. 8, p. 269, 1934; Smith, M. C., and Spector, H., Ariz. Agric. Expt. Sta. Tech. Bull., v. 84, p. 375, 1940; also later papers.

[6] Caveness, H. L., Satterfield, G. H., and Dann, W. J., Arch. Ophthalmol. (Chicago) v. 25, p. 827, 1941.

[7] Sie, B. L., Arch. Augenheilk., v. 110, p. 610, 1937.

[8] Steininger, G., Roberts, L. J., and Brenner, S., J.A.M.A., v. 113, p. 2381, 1939.

of vitamin A has recently been suggested[9] as more informative of the true nutritional level. A single dose of vitamin A (7,500 units) is given by mouth after 12 hours fasting and the concentration of this vitamin in the blood is determined at intervals over a 24-hour period. The resulting curve of blood levels following the test dose gives a clue to the relative amount taken up by the liver. In persons with low liver stores due to vitamin A deficient diets, more of the test dose goes to build up liver reserves and the curve of blood vitamin A is consistently lower than in those whose intake of this vitamin has been liberal or adequate.

NO VITAMIN A IS EXCRETED IN THE URINE under normal conditions, since it is not water-soluble. As previously noted, considerable unabsorbed carotene is normally found in the feces; this may be increased in amount, and some vitamin A fails of absorption in disorders where stools are loose and frequent. Since there is a considerable output of VITAMIN A IN MILK, the need for extra quantities of this vitamin is probably much greater in lactation than in pregnancy.

Human Requirement and Standard Allowance. Vitamin A values are stated in **International units,** rather than by weight. Since, as was stated above, carotenes are no more than 50 per cent absorbed and converted to vitamin A, it takes at least twice as much beta-carotene as vitamin A to produce the same effect on the body. One International unit is defined as equivalent to 0.6 MICROGRAMS OF PURE BETA-CAROTENE, or to 0.3 micrograms of pure vitamin A.

It will be evident that human requirement will differ according to whether the major part of the intake is in the form of vitamin A or of the less efficient precursors of this vitamin supplied in vegetable foods. One study[10] led to the conclusion that 2,500 INTERNATIONAL UNITS (I.U.) OF VITAMIN A OR 5,000 I.U. OF BETA-CAROTENE are sufficient to meet the daily requirement of normal ADULTS. The ALLOWANCE that is considered adequate for promotion of health will vary with the standard of health set. Sherman contends[11] (on the basis of animal experiments which may or may not apply to man) that intakes up to four times the quantity required to prevent deficiency symptoms will bring returns in health, delayed senility and longer life. Since most adults depend more heavily for their supply of this vitamin on foods that contain the provitamins A than on those

[9] Ruch, D. M., Brunsting, L. A., and Osterberg, A. E., Proc. Staff Meet., Mayo Clinic, v. 21, p. 209, 1946.

[10] Wagner, K. H., Z. physiol. Chem., v. 264, p. 163, 1940.

[11] Sherman, H. C., Campbell, H. L., Udiljak, and Yarmolinsky, H., Proc. Natl. Acad. Sci., v. 31, p. 107, 1945.

which supply preformed vitamin A, it is wise to put the standard allowance for vitamin A value of the diet rather high. A liberal allowance will not only cover possible deficient utilization but will permit of building up reserve stores in the liver which may protect health. CHILDREN need extra allowances of vitamin A for growth, while the needs of PREGNANT WOMEN and NURSING MOTHERS are also high. Figures for **daily allowances of vitamin A** that have been recently recommended[12] are given below:

	I.U.		*I.U.*
Normal adult	5000	Infants under 1 year	1500
Pregnancy (latter half)	6000	Children:	
Lactation	8000	1 to 3 years	2000
Children over 12 years	5000	4 to 6 years	2500
Except boys, 16 to 20 years	6000	7 to 9 years	3500
		10 to 12 years	4500

How to Get Daily Quota in Foods. As stated in International units the vitamin A allowances seem large, but each unit represents considerably less than a millionth of a gram of pure substance and 5000 I.U. would be equivalent to only 1.5 mg. of vitamin A. Although lack of enough vitamin A in the diet is a common fault, especially in low-income families,[13] it is not difficult to get the more liberal quantities recommended for health, provided foods are wisely chosen.

The most important **animal sources** of vitamin A are LIVER, BUTTERFAT, and EGG YOLK. Milk, cream, ice cream, and whole milk or cream cheeses all carry vitamin A in lesser amounts. The vitamin A value of these foods may vary widely according to the vitamin A value of the food of the animals that produced them. Livers from older animals and from those that are fed on green fodder contain much larger stores of vitamin A. Butterfat in the milk of cows is yellower and of higher vitamin A value when the animals are grazing in green pastures than when stall-fed in winter. Some egg yolks may have twice the vitamin A value of others. However, the yellowness of egg yolks and butterfat is not an infallible guide to their vitamin A value, since they contain both the yellow provitamins A and the colorless vitamin A.

Important **plant sources** of vitamin A value are the GREEN AND YELLOW VEGETABLES used as human food, as well as all green plants upon which farm animals feed. As the vitamin A value of plants is due entirely to yellow

[12] Recommended by Food and Nutrition Board, National Research Council, 1948.

[13] A study of diets of high school students of low-income families in New York City (Wiehl, D. G., Milbank Mem. Fund Quart., v. 20, p. 61, 1942) showed that about 40 per cent of them were getting less than two-thirds of the recommended amounts of vitamin A.

TABLE XX. VITAMIN A VALUE OF TYPICAL FOODS*

Food.	International units.		
	Per 100 grams.	Per average serving.†	
Liver, beef	19,200	2 oz. serving	11,500
Carrots (deep color)	12,000	¾ cup, cubed (100 gm.)	12,000
Green leafy vegetables (4000–15,000) average	7,875	½ cup, cooked (100 gm.)	7,875
Sweet potatoes (deep color)	7,700	1 medium-sized	7,700
Apricots, dried	7,430	4–6 halves	2,230
Squash, winter	4,950	½ cup, cooked	4,950
Broccoli	3,500	½ " "	3,500
Pumpkin	3,400	½ " "	3,400
Cantaloupe (deep color)	3,400	½ melon, 4½ in. diam.	5,100
Butter (2,000–4,000)	3,300	1 avg. pat (10 gm.)	330
Cheese, cream	2,210	1 oz. (rounded tbsp.)	627
" , Am., cheddar	1,740	1 oz.	493
Eggs, whole	1,140	1 avg. sized (50 gm.)	570
Tomatoes	1,100	1 medium, ripe	1,100
Asparagus, green	1,000	6 stalks, 4 in. long (50 gm.)	500
Cream, thin (20%)	830	½ cup (100 gm.)	830
Ice cream, avg., plain	540	2 small scoops (100 gm.)	540
Green vegetables, other than listed above, avg.	560	Avg. serving (100 gm.)	560
Yellow vegetables, other than listed above, avg.	330	" " "	330
Other vegetables, (10–90) avg.	35	" " "	34
Fruits, fresh:			
Apricots	2,790	2–3 medium	2,790
Peaches, avg. yellow	880	1 medium large	880
Watermelon	590	½ cup, cubes or balls	590
Others (10–400), avg.	145	Average serving (100 gm.)	145
Milk, whole, fresh	160	1 pint	780
Cereal products	negligible		
Lean meats	negligible		

* Figures from Tables of Food Composition, U. S. Dept. Agriculture, Misc. Pub. No. 572, 1945.

† Deductions for cooking losses (not made in this table) are 10–30 per cent for leafy vegetables, 20 per cent for other green and yellow vegetables, 7 per cent for potatoes and 5 per cent for other vegetables.

carotenoid pigments, either alone or formed in conjunction with chlorophyll, the depth of yellow or green color is a true index of their potential vitamin A value. Most thin green leaves (spinach, kale, turnip greens, etc.)

have a vitamin A value of from 5,000 to 15,000 International units (average about 8,000 I.U.) per 100 grams; bleached inner leaves of cabbage and lettuce (as well as bleached asparagus) are of low vitamin A value. Carrots may vary in vitamin A value from 2,000 to 12,000 I.U. per 100 grams and sweet potatoes also vary widely in vitamin A value according to the depth of their color. It must be remembered that human beings cannot utilize all of the POTENTIAL vitamin A value of plant foods. Average vitamin A values of other green and yellow vegetables and yellow fruits are given in Table XX on p. 271.

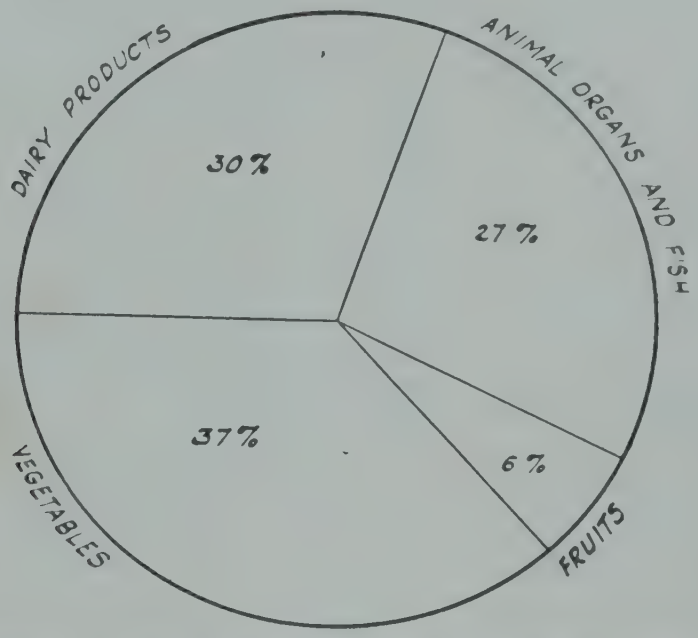


Fig. 44. Percentages of vitamin A value contributed by various food groups in the average American diet. (Booher in Wohl: Dietotherapy, W. B. Saunders Co.)

Grains, sugar, and vegetable oils carry little or no vitamin A, while lean muscle meats, nuts and many common fruits and vegetables provide only minor quantities of this vitamin. The body fat of animals usually contains little vitamin A, but that of fish may contain considerable amounts of this vitamin.

Combinations of FOODS THAT WILL PROVIDE THE STANDARD DAILY ALLOWANCE OF VITAMIN A FOR AN ADULT are given below. Since the plant provitamins are not so efficiently utilized, it is advisable that foods of animal origin should provide part of the vitamin A in the diet. EACH of the following food combinations will furnish just over 5,000 I.U. of vitamin A:

1 pint of milk	3 tbsp. butter	2 eggs
½ sweet potato	avg. svg. broccoli	4–6 dried apricot halves
2 halves canned peaches	1 banana	6 oz. tomato juice

There is danger that the diet will provide less than optimum amounts of vitamin A unless green and yellow vegetables are used frequently. This may be shown by the fact that the following group of foods, which might seem to constitute the basis of a "good" diet, falls considerably short of the 5,000 I.U. daily vitamin A allowance.

1 pint of milk 3 squares butter 1 egg 8 oz. orange juice 1 avg. svg. fresh fruit 3 avg. svgs. vegetables, NOT green or yellow	furnish approximately 3,000 I. U. of vitamin A

If one of the vegetables served were of the green or yellow variety, the vitamin A value of this diet would be raised decidedly, usually up to the 5,000 I.U. level or more, provided the vegetable chosen is strongly colored.

Since vitamin A and its precursors (the carotenes) are insoluble in water and stable to heat at ordinary cooking temperatures, FOODS LOSE LITTLE OF THEIR VITAMIN A VALUE IN COOKING OR CANNING. Drying, especially of unsulfured fruits, in sunlight, or at high temperature for a long period, may cause serious loss of vitamin A value. Pasteurization or irradiation of milk has little or no effect on its vitamin A content. Vegetables should be stored at low temperatures to conserve their vitamin A value and, of course, quick freezing is an excellent means to this end. Animal fats should be kept in a cold dark place, and fish liver oils should be protected from light by being put in a dark glass bottle.

Fish liver oils, the richest source of vitamin A, vary in vitamin content with the species of fish. Standard cod liver oil (850 I.U. per gram) contains 4 times as much vitamin A as raw beef liver (the richest food source), but liver oil from halibut is 60-100 times as rich in this vitamin and that from swordfish about 300 times as rich as cod liver oil. Liver and body oils of the shark, seal and whale are newer sources of vitamin A. Capsules of liver oil concentrates (dissolved in neutral oil) usually contain the daily adult allowance, 5,000 I.U., but may be obtained for therapeutic use in high potency (up to 50,000 I.U. or more per capsule). Enormous doses of vitamin A may be toxic and long-continued moderate doses (5,000-10,000 I.U. per day) have been shown to be better for building up stores of this vitamin in the liver. Two teaspoons of cod liver oil will provide over 6,000 I.U., all of it in the readily assimilable form of preformed vitamin A.

VITAMIN D

Cod liver oil had long been established as an excellent preventive for rickets before the reason for its potency was accounted for by science. In

1921, McCollum and co-workers found that, after destruction of all vitamin A in cod liver oil, it still retained its rickets-preventing potency. This indicated the existence of a second fat-soluble vitamin, carried in liver oils and certain other fats, which was called the ANTIRACHITIC VITAMIN OR VITAMIN D. Recent work has shown that there are some ten substances which exert vitamin D-like activity in varying degrees, but only two of these are of practical importance (D_2 and D_3). Since all of them are closely related chemically and produce a like effect on the body, the term vitamin D is often used collectively to indicate the GROUP of substances that show vitamin activity.

Vitamins D_2 and D_3, and Their Precursors. Steenbock and Hess discovered independently (in 1924) that when certain foods were exposed to ultraviolet light their ability to protect animals against rickets was increased. This meant that precursors of vitamin D must be present in foods, substances which are altered chemically by light of certain wave-lengths so that they become able to function as vitamins in the body. We now know that the **provitamin D** in plants is a different substance from the animal precursor, and that each gives rise to a slightly different vitamin D when activated by light. In plants, a substance known as ERGOSTEROL is converted by light into vitamin D_2; in animals, a derivative of CHOLESTEROL is the precursor of vitamin D_3. Vitamins D_2 and D_3 are very similar chemically and in their vitamin activity. Apparently birds respond better to vitamin D_3, but most animals can utilize either type of vitamin D. Vitamin D_3 occurs in fish liver oils and foods of animal origin, such as eggs, butter, milk and cream. Vitamin D_2 has been prepared in concentrated form by "irradiation" of yeast, and is sold as pure crystals under the name of **calciferol** and in solution in neutral oil as VIOSTEROL.

Formation of Vitamin D in the Body by Sunlight. Provitamin D_3 is present in the skin and tissues immediately underneath. Hence it is not surprising that, when SUNLIGHT in which there is light of short wavelengths (ultraviolet light) falls directly upon the skin, some of the provitamin will be converted into vitamin D_3. If the vitamin is formed in oily secretions on the skin, it can be absorbed through the skin; if it is formed in the skin, it is readily taken into the local circulation and thus carried to all parts of the body. Excess formed over immediate body needs can be stored in fatty tissues and may be found in such organs as the liver, lungs, spleen and brain.

Hess found that rickets could be prevented or cured by exposing children (without clothing) to sunlight or the rays of an ULTRAVIOLET LAMP, since they thus were enabled to manufacture vitamin D in their own bod-

ies. Overexposure to ultraviolet rays causes sunburn and a toxic condition in the body, so that the time of exposure should be brief, especially with so-called "sunlight lamps" whose light contains more of the potent ultraviolet rays than natural sunlight.

The lower animals also generate vitamin D in their bodies on exposure to light. Steenbock kept chicks indoors on a vitamin D-poor ration, con-

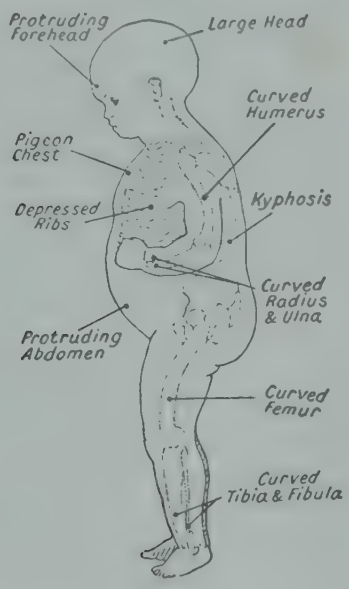


Fig. 45. Effect of exposure to sunlight in stimulating growth. Both chicks received the same ration, which was poor in vitamin D, but the one on the right was exposed to sunlight one half hour daily, thus generating the needed vitamin D in its body. (Courtesy of Dr. H. Steenbock, University of Wisconsin.)

ditions which led to stunted growth and leg weakness; exposure to sunlight for a half hour daily served to protect the chicks against these effects of vitamin D lack (see Fig. 45). Hens and cows, when allowed outdoor life in sunny regions, produce eggs and milk of higher vitamin D content. Because vitamin D is the ONLY vitamin that can be formed in the animal body by means of light, it is sometimes referred to as "the sunshine vitamin."

Rickets and Other Effects of Vitamin D Deficiency. The effects of a lack of this vitamin, as seen most strikingly in young animals, are failure to make proper GROWTH, lack of normal development of the BONES, and a tendency to increased susceptibility to INFECTIONS.

Rickets is a bone disease that occurs in children (usually under two years of age) and young animals, and it is generally closely associated with **lack of vitamin D,** although this is not the only factor involved. The metabolism of calcium and phosphorus is disturbed in such a way that the deposition in the bones of the inorganic salt (calcium phosphate), which is responsible for bone rigidity, cannot proceed normally. Hence this disease is characterized by weak bones, which readily develop curvatures



A

Fig. 46*A*. Diagram showing deformities that are symptoms of severe cases of rickets. (Harris, L. J., Vitamins in Theory and Practice, Macmillan Co.)

when compelled to carry the weight of the body (Figs. 46*A* and 47), and by overgrowth of the softer tissues (cartilage) at the ends of the bones. Rachitic deformities develop such as BOW LEGS, KNOCK KNEES, ENLARGEMENT OF bones about the JOINTS, and a NARROW, DISTORTED CHEST with "beading" of the ribs. These deformities, not themselves causing death, may persist into adult life, when the shrunken chest may predispose to lung diseases, often fatal (especially pneumonia), and a narrow pelvis may make child-bearing difficult for women. Rachitic children (see Figs. 19 and 47) are often irritable and nervous (or listless and disinclined to play), pigeon-breasted, pot-bellied, and with peculiar shaped heads, in addition to having deformities of arm and leg bones. Milder cases of rickets, asso-

ciated with less severe lack of vitamin D, may be detectable only by failure of bones to grow properly in length and by x-ray pictures, which show the characteristic failure of normal deposition of calcium phosphate in the ends of the bones (Fig. 46*B*, below).



B C

Fig. 46*B*. X-ray of joint that shows extreme rachitic changes in a ten-year-old Mexican boy.

Fig. 46*C*. Same after rapid healing has taken place as the result of very large doses of vitamin D; interval between B and C only one month. (McCune in Wohl: Dietotherapy, W. B. Saunders Co.)

Osteomalacia is a softening or weakness of bone that occurs in adults, especially at adolescence or in pregnancy, due to the fact that the bones have been robbed of part of the mineral deposits made in earlier years. Such a depletion of bone stores of calcium and phosphorus may be caused either by poor utilization of these mineral elements associated with vitamin

D lack, or by an insufficient supply of calcium or phosphorus in the diet to meet body needs.

It should be obvious that **rickets** may also be caused by **lack of either calcium or phosphorus,** since these are the building materials for the calcium phosphate upon which the rigidity and strength of bone depends. No amount of vitamin D will serve to promote normal bone development unless the mineral elements necessary for building strong bones are pro-



Fig. 47. Child suffering from severe rickets. Note knock-knees, flat feet, enlarged joints and other skeletal deformities accompanied by very poor posture. (Wisconsin Alumni Research Foundation.)

vided in the diet in adequate quantities. Conversely, rickets may develop on diets that supply plenty of calcium and phosphorus (*e. g.*, in infants on milk diet) if **vitamin D is lacking.** The vitamin D may be supplied in food or fish liver oil, or it may be generated in the body by exposure to sunlight, or some may be obtained from both sources. A diet rich in one of the necessary mineral elements and poor in the other predisposes toward development of rickets. The best PROTECTION against this disease and the most favorable bone growth is secured when calcium and phosphorus are sup-

plied in approximately equal amounts (as in milk) and liberal quantities of vitamin D are available.

Rickets formerly was a common disease among young children, so prevalent among children of the poor who lived in dark tenements in cities that it became known as "the disease of poverty and darkness." Under these conditions, both poor diet and lack of sunlight contributed to its development. In tropical regions and with country children, exposure to sunlight often protected against rickets even when the mineral content of the diet was not above reproach.

Since knowledge of the importance of vitamin D has been appreciated and the practice of giving cod liver oil to young children has become widespread, severe cases of rickets are seldom seen in the United States, although mild rickets is still of fairly common occurrence. This is well illustrated by statistics of preschool children in Chicago; from 1926–1932, examination showed 16–21 per cent with definite evidence of rickets, but by 1935 the percentage fell to 7 per cent with only 0.03 per cent of cases of severe rickets. The incidence of severe rickets, on the basis of these 1935 figures, had been reduced to three cases per ten thousand children. It is clear that rickets as a "disease" is well on the way to being eradicated in this country, but there are doubtless very many children who do not make full growth and proper development of bones and teeth because of lack of "optimum" amounts of calcium, phosphorus, or vitamin D.

Function of Vitamin D in the Body. It is still something of a mystery just how vitamin D works to foster growth and proper mineralization of the skeleton. Its chief rôle seems to be to PROMOTE BETTER ABSORPTION OF CALCIUM (and secondarily also of phosphorus) from the intestine, thus keeping the level of calcium and phosphorus in the blood up to levels that are favorable for deposition of calcium phosphate in the bones. This is the view taken by Nicolaysen,[14] who found that the extent of calcification of bones seemed to be determined solely by the amount of calcium and phosphorus brought to them by the blood, although the ARCHITECTURE of bones (crystalline structure on which their strength is dependent) IS influenced by vitamin D. Other investigators[15] suggest, on the basis of experiments with radioactive phosphorus, that vitamin D may influence bone formation favorably by aiding in the conversion of organic phosphorus to inorganic phosphorus compounds such as are deposited in bone. Others believe that vitamin D exerts some sort of controlling action over the

[14] Biochem. J., v. 31, 1937, several papers, and Acta Pediat., v. 23, p. 405, 1939.
[15] Cohn, W. E., and Greenberg, D. M., J. Biol. Chem., v. 130, p. 633, 1939.

process of calcification at the ends of growing bones and in the healing of bone fractures. We do know that with decided lack of this vitamin, as in rickets, there are subnormal levels of calcium and phosphorus and abnormally high phosphatase (enzyme that converts organic to inorganic phosphorus compounds) in the blood, as well as increased excretion of calcium and phosphorus. Although its mode of action is not clear, there is no doubt that vitamin D promotes more COMPLETE UTILIZATION OF MINERAL ELEMENTS supplied in the diet, especially calcium and phosphorus.

Vitamin D is also known to be essential for **growth,** and for formation of enamel and proper calcification of **teeth.** Lack of it seems to be ONE of the factors that favor tooth decay (dental caries).

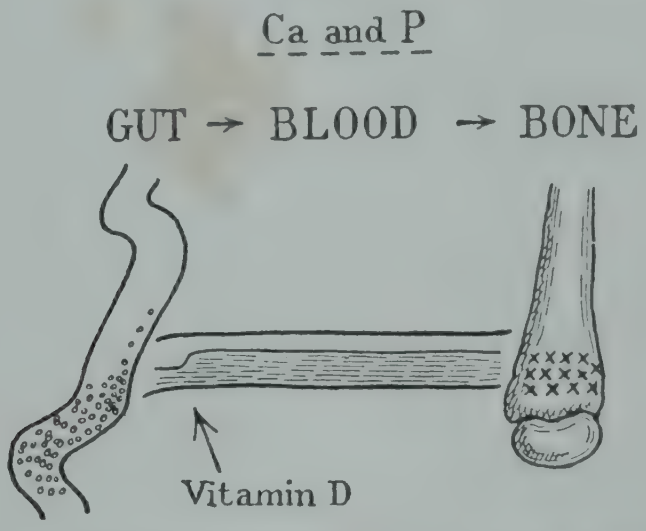


Fig. 48. Diagram to indicate how vitamin D may function by increasing absorption of calcium and phosphorus from the gut, thus raising their level in the blood and promoting their deposition in bone. (Harris, L. J.: Vitamins in Theory and Practice, 1937, Macmillan Co.)

Human Requirements. Another baffling fact is that it is impossible to state definitely HOW MUCH vitamin D we need. We can estimate fairly well the amount of it supplied in foods, but there is no way of knowing how much extra vitamin D is made in the body under the influence of sunlight. Since its action is chiefly concerned with the metabolism of bones, which are hidden and relatively inactive tissues, it is difficult to tell whether an adult is or is not getting enough of this vitamin to keep the body in best condition. With YOUNG CHILDREN, when rapid growth and calcification of bones should be taking place, the need for vitamin D is relatively greater and a deficiency of it will be evidenced by slower growth, and possibly by weak or malformed bones. Hence it is easier to gauge the vitamin D requirements of infants and young children. But even with infants there are

considerable differences, since preparations of D_2 and D_3 vary in effectiveness and numerous conditions may influence the degree to which vitamin D is utilized.

Vitamin D is measured in International units, ONE UNIT corresponding to the vitamin activity of 0.025 MICROGRAMS OF PURE CALCIFEROL (vitamin D_2). Extensive studies on prevention of rickets enable us to say that 135 International units (I.U.) daily of vitamin D_3 (the "animal form") will usually protect infants from rickets, provided their diet includes a quart of milk each day (to supply calcium and phosphorus in plentiful, readily assimilable amounts).[16] Most pediatricians favor fish liver oils as a source of vitamin D (D_3) for infants in preference to viosterol (D_2), although either form of the vitamin is effective and the supposed extra efficiency of fish liver oils is probably at least partially due to their content of vitamin A (not present in viosterol). Although rickets may be prevented by smaller amounts of vitamin D, a daily intake of 300 to 400 I.U. seems to be needed to support a rate of growth and development "nearer the top of the normal range." Doses of 300–600 units daily show a maximum effect on the linear growth (length) of infants.[17]

Less is known about the vitamin D requirements of older children than of infants. Jeans and Stearns studied children from 1 to 12 years of age, with varying intakes of milk and with or without added vitamin D (in the form of cod liver oil). Those who received cod liver oil got 300 to 400 I.U. per day from this source. They found that children varied widely in their utilization of calcium and in their vitamin D need. Those who had good utilization of calcium without added vitamin D, showed little improvement in this respect when cod liver oil was given; but if the original utilization was poor, additional vitamin D increased the retention of calcium in the body. The National Research Council's Food and Nutrition Board recommends 400 I.U. of vitamin D daily for children from birth to 20 years of age.

The same board quoted above has recently (1948) made the following statement as to vitamin D needs of adults: "The need for supplemental vitamin D by vigorous adults leading a normal life seems to be minimum. For persons working at night and for nuns and others whose

[16] Jeans, P. C., and Stearns, G., THE HUMAN REQUIREMENT OF VITAMIN D, J.A.M.A., v. 111, p. 705, reprinted as Chap. XXVI of THE VITAMINS, published by A.M.A., 1939.

[17] Slyker, Hamil, Poole, Cooley, and Macy, Proc. Soc. Exp. Biol. and Med., v. 37, p. 499, 1937; and reference in footnote 16, above; Stearns, Jeans, and Vandecar, J. Pediat., v. 9, p. 1, 1936; Jeans and Stearns, J. Pediat., v. 13, p. 780, 1938; Spiedel and Stearns, J. Pediat., v. 17, p. 506, 1940.

habits shield them from the sunlight, as well as for elderly persons, the ingestion of small amounts of vitamin D is desirable." This means that most normal adults get enough of this vitamin, either in their food or by exposure to sunlight, to meet at least their minimum needs.

However, during pregnancy and lactation supplemental vitamin D (400 I.U.) daily is recommended. A liberal supply at these periods is undoubtedly wise since, even though transmission to the fetus and milk is relatively low, the stores of vitamin D in the baby's body and the vitamin D content of milk are appreciably increased by vitamin D in the diet of the mother.

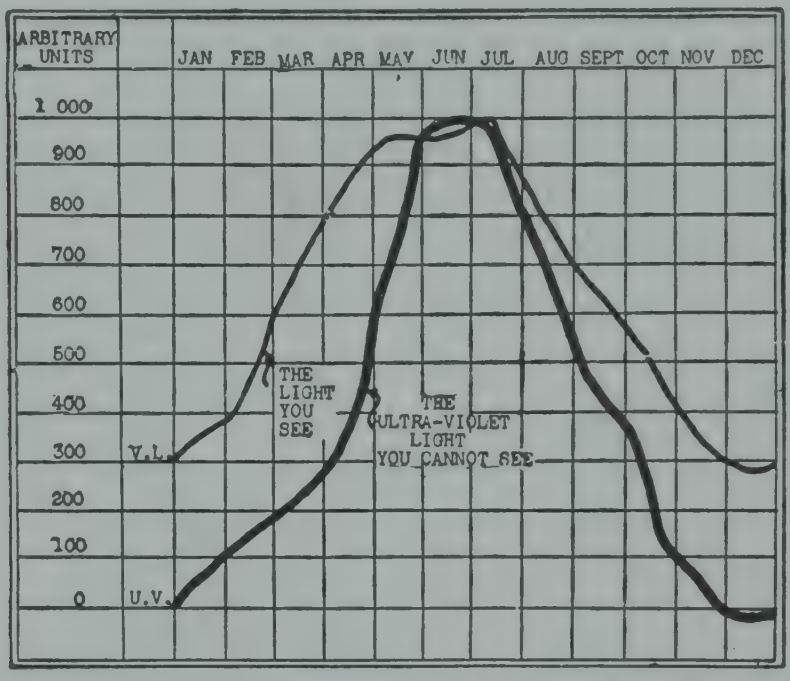


Fig. 49. Seasonal variations of the sun's spectrum: V. L., visible light; U.V., ultraviolet light. (From Hess and Lundagen, *Journal of the American Medical Association*, v. 79, p. 2211, 1922.)

It should be remembered that poor absorption of vitamin D may be a causative factor in inducing lack of it. Like other fat-soluble vitamins, its absorption from the intestine is dependent upon the presence of bile and other factors that make for good absorption of fats, and is unfavorably influenced by the presence of mineral oil. However, effective absorption of the food intake is not so important in the case of vitamin D as with other vitamins, since supplementary amounts of it can be made in the body.

The amount of vitamin D that will be made in the body through exposure to sunlight will vary according to the SEASON, the LOCALITY in which one lives, and one's life HABITS. In the tropics bright sunlight is available

the year round, but in most other parts of the world sunlight is scarce during the winter months. Sunlight also is richer in ultraviolet rays in summer (see Fig. 49) and more of these rays get through to the "consumer" when the sun is directly overhead, *i. e.*, between 10 A. M. and 2 P. M. On cloudy or foggy days and in cities covered by smoke pall almost all of the ultraviolet rays are screened out before light penetrates to the people. Window glass and layers of clothing also effectively prevent ultraviolet rays from reaching the skin. As only the ultraviolet rays (light of short wave-length and high frequency) have the ability to bring about the chemical change by which vitamin D is formed, persons who live in cities can place little dependence upon making this vitamin in their own bodies, especially in winter. Others who live and work outdoors in sunny regions will manufacture considerable vitamin D with the aid of sunlight, and hence will be less dependent on food for it.

Vitamin D in Food. Nature's plan seems to have been that man should generate part of his supply of this vitamin by sunlight, for it is contained more sparsely in foods than any other well-known vitamin. Although most vitamins are formed in green plants, vitamin D is present either not at all, or only in minute traces in vegetable foods. It is present in somewhat larger but very variable amounts (associated with vitamin A) in fatty foods of animal origin—EGG YOLK, BUTTERFAT, and the BODY FAT OF FISH. Since it, in common with other fat-soluble vitamins, can be stored in the liver, LIVER is a fair source and FISH LIVER OILS are a rich source of vitamin D. There is little destruction of this vitamin in cooking, as it is stable to heat, and its insolubility in water prevents loss in cooking water.

From Table XXI, which shows the vitamin D content of foods, it will be evident that it is difficult to get an adequate supply in the diet. Among common foods only eggs and butter furnish it in appreciable amounts; it is present in milk and cream only in minor quantities, while liver and fatty fish are infrequently used foods. Deep red varieties of salmon carry much more vitamin D than the pale pink (Chinook) salmon. In an average "good" diet, which includes daily 1 egg, 3 tablespoons of butter and a pint of milk, one would get from 40–160 I.U. of vitamin D (varying with whether the egg yolk and butter happened to be rich or poor in this vitamin). Many adults seem to get on at least fairly well with the amount of vitamin D provided in foods plus that which they generate under the influence of sunlight. The vitamin D needs of normal adults may be less than commonly supposed; on the other hand, it is possible that the higher intakes, suggested by nutritionists as desirable (135–400 I.U. daily), would

make for healthier adults. To meet the greater needs of CHILDREN and PREGNANT WOMEN (400 I.U. daily) some SUPPLEMENTARY SOURCE of vitamin D is essential, especially during the winter months.

TABLE XXI. VITAMIN D IN FOODS IN INTERNATIONAL UNITS

Food.	Per 100 grams.	Per average serving.	
Cod liver oil, U.S.P. standard	8,500	1 teaspoon	314
Salmon, canned	225–800	½ cup	135–480
Salmon, fresh	260–400	3 oz. serving	220–340
Eggs	22–160	1 egg	11–80
Butter	40–150	Avg. square (10 gm.)	4–15
		1 tablespoon	6–23
Liver	15–45	3 oz. serving	13–38
Cream, heavy (40% fat)	20	¼ cup or 4 tbsp	12
Cream, light (20% fat)	10	¼ cup or 4 tbsp	6
Milk, whole, fresh	2	1 cup or glass	4
		1 quart	20
Milk, vitamin D	14–41	1 quart	135–400
Breakfast cereal, enriched	1,320	1 oz. dry or ¾ cup cooked	400

Enriched Foods and Other Rich Sources of Vitamin D. COD LIVER OIL is the time-honored supplementary source of this vitamin for children. It varies in vitamin D potency, but standard cod liver oil supplies no less than 85 I.U. per gram, which means at least 300 I.U. in a teaspoonful, and one or two teaspoons daily is the dose recommended for young children and pregnant women. Liver oils from certain other fish are richer in vitamin D than is cod liver oil; CONCENTRATES made from such oils may be taken in capsules and often carry as much as 1000 I.U. of vitamin D per capsule. VIOSTEROL (an extremely concentrated solution of vitamin D_2 in neutral oil) is preferred by some because it is tasteless, but only a few drops of it are needed daily.

Enough is better than too much, as far as vitamin D is concerned. Single large doses may be used without harm but smaller overdoses, if taken daily, are likely to produce undesirable results. Some pediatricians suggest giving infants single massive doses at long intervals (instead of small daily doses), and find[18] that a single dose of 300,000 I.U. by mouth will be stored in sufficient amounts to protect children, without exposure to sunlight, from rickets for six months. There is some evidence that DAILY doses of 1,800 I.U. or more will retard rather than increase growth. Vita-

[18] Wolf, I. J., J. Pediat., v. 22, pp. 396 and 707, 1943; *idem.*, v. 24, p. 167, 1944.

min D shows toxic effects in daily doses over 20,000 I.U. per kg. body weight which is about $\frac{1}{300}$ the size of toxic doses of vitamin A.[19] When enormous doses are taken over long periods, as sometimes given for arthritis and other diseased conditions, there is high blood calcium and various serious effects may follow.[20] Moderate doses may be taken without fear of harm and usually give the maximum benefit that may be expected.

Since it became known that the low natural vitamin D content of foods could be increased by "irradiation" with ultraviolet light, nutritionists have

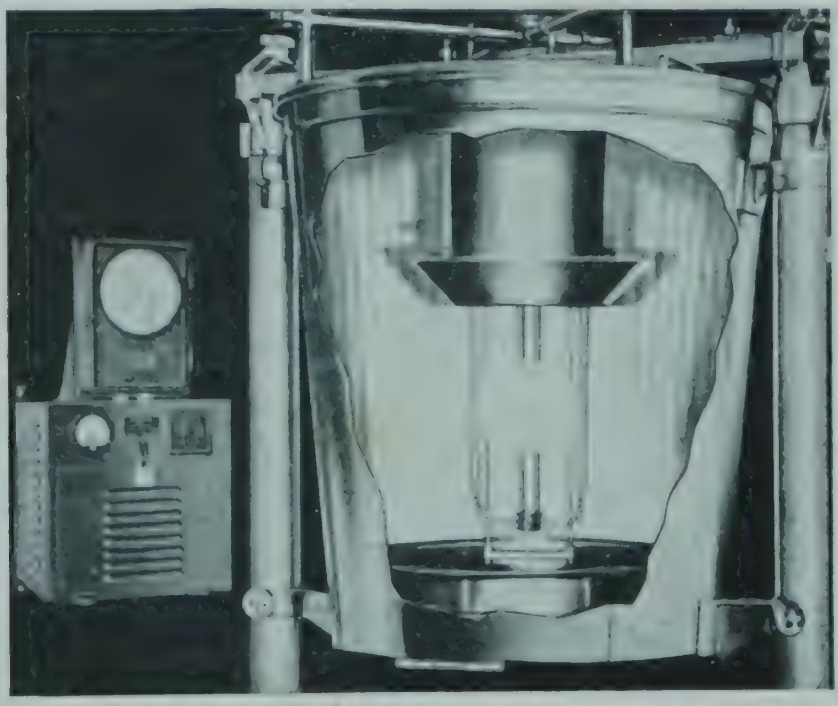


Fig. 50. Process of making "vitamin D milk" by irradiation. Ultraviolet rays from a carbon-arc lamp shine for a few seconds on a thin film of milk, which flows down the sides of a large cylindrical tank. By regulating the speed of the milk flow and the amount of electrical current used (by control cabinet shown at left), the vitamin D potency of the milk can be controlled. (Courtesy of Irradiated Evaporated Milk Institute, Chicago.)

favored the ENRICHING or reinforcing of a few staple foods with this vitamin as the easiest way to make certain that everyone gets enough of it. The process has been controlled by patent in order to avoid its indiscriminate use with many foods. MILK is the chief food which has thus far been enriched as to vitamin D. MARGARINES have also been reinforced with this vitamin (and vitamin A) to make them acceptable nutritionally as substi-

[19] Jones, J. H., J. Nutrition, v. 28, p. 7, 1944; Nutrition Rev., v. 3, no. 10, Oct., 1945.

[20] "Toxicity of the Vitamins," Nutrition, Rev., v. 5, p. 49, 1947.

tutes for butter. The minimum and maximum vitamin D content of such foods is controlled by food regulations, and is shown in the table on page 284 for vitamin D milk. One method of making VITAMIN D MILK by IRRADIATION is shown in Fig. 50. Milk has also been enriched with vitamin D by addition of a standard amount of fat-free, tasteless concentrate from cod liver oil, or by feeding irradiated yeast to cows. A quart of vitamin D milk daily will protect a child against rickets and also will supply the calcium and phosphorus needed to build strong bones. Evaporated and dried milks have also been irradiated to increase vitamin D content (1 can irradiated evaporated milk, 325 I.U. vitamin D) and a few special breakfast cereals are enriched as to this vitamin. One such food reinforced as to vitamin D in the diet would insure a liberal supply of this vitamin to those who live in northern climates or in cities where sunlight is seldom available.

Two **other fat-soluble vitamins** are known which are of considerable scientific interest. Both occur in two or more forms, which have been isolated from foods and synthesized in the laboratory. Both are soluble in fat solvents and are stable to heat, but lose their vitamin activity on oxidation. A brief description of these two vitamins will suffice for our purposes because (1) their relation to human nutrition has not yet been established, and (2) their distribution in foods is such that there is little likelihood of deficiency in the normal human dietary.

VITAMIN E

This vitamin has been known since 1922 to be an essential factor for **reproduction,** although our knowledge of its effects has been obtained almost exclusively by experiments on lower animals. It occurs naturally in three forms (known as alpha, beta, and gamma tocopherol), all of which have been synthesized, but we still refer to the group of substances with like vitamin activity as vitamin E.

In rats which have been deprived of vitamin E, the males become permanently sterile and pregnant females are unable to carry young to term, since lack of this vitamin results in death and reabsorption of the embryos in the uterus. Fertility of female rats is not destroyed and, when given sufficient vitamin E later, they give birth to normal litters. Administration of this vitamin has been thought to be of benefit in preventing repeated abortions in cattle, but its value for the prevention of human abortions is doubtful. Young rats (and other animals) after several months on E-deficient diets FAIL TO GROW NORMALLY and also develop WEAKNESS AND DEGENERATION OF THE MUSCLES, a condition known as MUSCULAR DYSTROPHY.

However, it is very questionable whether vitamin E is of any benefit to human sufferers from muscular dystrophy.

The most striking chemical property of vitamin E is its ability to prevent or slow down oxidation of other substances. It has been shown to protect both vitamin A and carotene from destruction by oxidation, especially in the alimentary tract. In this way, vitamin E exerts a sparing action and "stretches" the supply of vitamin A available to the body.[21] It has been questioned whether some of the physiological effects formerly attributed to vitamin E lack may not be due to the reduced supplies of vitamin A that result on a vitamin E poor diet. Wheat germ oil is the richest source of this vitamin but it is found in many foods (whole grains, leafy vegetables, meat and milk), so that there is little chance of shortage of it in normal diets.

VITAMIN K

This vitamin was discovered in 1935 by Dam of Copenhagen, who designated it by the letter K to stand for "koagulation" (the Danish spelling of the word). Its function is to assist in the formation in the liver of an enzyme called PROTHROMBIN, which is necessary for the coagulation or clotting of blood. In chicks deprived of this vitamin, there are hemorrhages under the skin, often serious internal bleeding, and delayed clotting time of the blood. Doses of vitamin K restore blood-clotting time to normal, and thus prevent loss of blood by hemorrhages.

This vitamin is found abundantly in green leaves (spinach, kale, alfalfa, etc.) and is probably supplied in adequate amounts in the human dietary. But the presence of bile in the intestine seems to be necessary for its satisfactory absorption from the food, and too little of it may be absorbed to meet body needs if the normal flow of bile from liver to intestine is obstructed for any reason. Hence patients with diseases of the biliary tract (such as obstructive jaundice) are likely to suffer from deficiency of vitamin K (even though there is plenty of it in the diet), which is manifested by INABILITY OF THE BLOOD TO CLOT PROMPTLY. Injuries or surgical operations in such cases may result in dangerous hemorrhages. Doses of vitamin K, given along with bile salts, have proved effective in raising the level of prothrombin in the blood and thus restoring the normal clotting ability of the blood. Similarly, newborn infants sometimes suffer from severe hemorrhages and it is known that there is normally a low level of prothrombin in the blood at birth. For this reason many physicians favor the administra-

[21] Hickman, K. C., Harris, P. L., *et al.*, J. Biol. Chem., v. 152, pp. 303, 313, and 321, 1944.

tion of vitamin K either to the mother before delivery or to the infant at birth.

Concentrated preparations of vitamin K for such therapeutic uses are made either from alfalfa or from putrified fish livers, where it has been formed by action of bacteria. Both naturally occurring forms of the vitamin (K_1 and K_2) have been synthesized, as well as chemically related substances that possess some degree of vitamin K activity.

Food sources of vitamin K include all of the green leafy vegetables, egg yolk, soybean oil and liver. Another source of this vitamin is its formation by bacteria in the intestine, perhaps from precursors in the food. In experimental animals, the administration of sulfa drugs, which reduce the numbers of bacteria in the intestines, resulted in vitamin K deficiency as evidenced by lowered levels of prothrombin in the blood.[22] Vitamin K deficiency in man seldom results from lack of this vitamin in the diet (or formation by action of intestinal bacteria), but arises from abnormal conditions that interfere with its absorption and utilization.

QUESTIONS AND PROBLEMS

1. Tell how fat-soluble vitamins differ from water-soluble ones in each of the following respects: solubilities, types of food in which they are carried, losses in cooking and processing foods, conditions necessary for good absorption from intestine, path or paths of excretion, ability to be stored in the body.

2. Name four fat-soluble vitamins and give for each one its chief use (or uses) in the body, and the effects of moderate and severe lack of it in the diet. How does its function in nutrition account for the type of symptoms that result from an insufficient supply?

3. What is meant by provitamins or vitamin precursors? Name the precursors of vitamin A and tell in what classes of foods they are found. How and to what extent are they made into vitamin A in the body? What foods contain both the provitamins A and vitamin A? Which contain only preformed vitamin A? What determines whether the vitamin A value of eggs, milk and butter is high or low? Is the depth of color of egg yolk and milk fat a reliable index of their vitamin A value, and why? Does the depth of color of green and yellow vegetables indicate their relative vitamin A value, and why?

4. List ten vegetables and three fruits of high vitamin A value; list the five foods of animal origin that are the richest sources of vitamin A (con-

[22] Black, Elvejhem, *et al.*, J. Biol. Chem., v. 145, p. 137, 1942; Kornberg, Daft and Sebrell, *idem.*, v. 155, p. 193, 1944.

sult tables on p. 271 and in Appendix for vitamin A values of individual foods).

5. Plan a diet that will furnish 2,500 International units of vitamin A; modify this diet so that it will provide 5,000 I.U. vitamin A; substitute foods or add some rich sources of vitamin A, so that the diet as modified will supply 10,000 I.U. (or more) of vitamin A. Is it difficult to get as much as 5,000 I.U. (recommended daily allowance for adults) in the diet? What will happen if the diet supplies 2,500 I.U. one day and 10,000 I.U. the next day? Of what advantage is it to have an intake of vitamin A considerably in excess of the minimum requirement?

6. What are the precursors of vitamin D and where are they found? By what means are they transformed into vitamin D? Under what circumstances can this vitamin be made in the body? Under what conditions will persons make little of this vitamin in their bodies and so be dependent almost entirely on food sources for their supply of vitamin D? What foods carry small and variable amounts of vitamin D? How may the natural low content of vitamin D in foods be increased? What foods have been reinforced as to their vitamin D content?

7. At what periods of life is the need for vitamins A and D relatively high, and why? What rich source (or sources) of these vitamins is usually given at these periods to insure a plentiful supply of vitamins A and D? Why will a baby that is breast-fed derive more benefit if supplementary vitamins A and D are given to it directly than if they are given to its mother?

8. How may incipient rickets be detected? How can rickets be prevented? How can it be cured? What are the earliest symptoms of vitamin A lack? What course would you recommend for getting rid of such symptoms?

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PART

3

BODY PROCESSES

CHAPTER 17

THE BODY AS A WHOLE IN ITS RELATIONS TO FOOD

In the early textbooks and writings about nutrition, the scope of the subject was almost entirely limited to setting forth what the body needed and how to supply these wants in the food—fuel, material for repair, and regulating materials. If these were supplied in proper amounts in the diet, it might be supposed that the machine would run smoothly for an indefinite period. "Sufficient calories and a balanced diet" was the slogan, and **nutrition** was almost synonymous with **food requirements.** Now we know that this scheme makes matters look simpler than they really are.

The body is NOT a machine and therein lies the dilemma. If it were, we COULD simply feed in the necessary amounts of various food materials and receive health as the finished product of a perfectly functioning mechanism. But the **body is a complex living organism.** Its different parts act and react upon each other in mutual adjustments quite impossible to any machine. Furthermore, the machine is practically unaffected by its environment, whereas the human body is played upon by many different stimuli from without, and by thoughts and emotions from within.

In recent years we have been forced to face the problem that food is not all that there is to nutrition by finding an increasing number of persons, who are receiving plenty of good food, but who nevertheless are not properly nourished. They may be either over or under nourished, either carrying about a burden of excessive fat or too thin, with low vitality and endurance, or they may be normal in weight but under par in health. Gradually we are coming to the realization that nutrition should be considered from the standpoint of the **body as a whole in its relation to food.** We cannot talk of one food as being wholesome and another unwholesome without taking into account the relative conditions of the individual when the two foods were eaten; we cannot speak of the stomach and the processes going on in it as if they were independent of the rest of the body; we cannot build a healthy body as a result of taking an adequate diet, when the food is eaten under conditions of habitual strain and over-

fatigue. In a hundred different ways nutrition is affected by inter-relations between food and the body, between the different parts of the body, and between the body and its environment.

In short, there are two main aspects of nutrition—THE FOOD INTAKE AND WHAT THE BODY DOES WITH IT—and the second of these is equally important with the first, since the condition of the person who receives the food determines how much or how little he is able to profit by it.

In view of this broader meaning of nutrition, it seems advisable to take up in this chapter some of the more general factors which are directly or indirectly concerned in the nourishment of the individual. The vital importance of taking these factors into consideration when one attempts to rebuild the health of malnourished persons, has been established by successful application.

GENERAL FACTORS WHICH INFLUENCE NUTRITION

1. Type of Individual
2. Physical Defects
3. Body Mechanics
4. Overfatigue
5. Mental and Social Factors
6. Habits
   a. General health habits
   b. Food habits

Type of Individual. There is nothing new under the sun and it has long been recognized, even by casual observers of the human race, that we have one type of individual who tends to be tall and thin, while another type of person inherits a short and stocky build. Brillat-Savarin, a French connoisseur of food and keen observer, who about 1825 wrote a treatise on "gastronomy" which was the last word on nutrition for that day, noted the "natural predisposition to corpulence" and described this type of person as having "a short face, round eyes, a flat nose, and an amiable, lively disposition." He also described the type that is disposed to leanness as having "an elongated shape, small hands and feet, slender legs and back, prominent ribs, aquiline nose, long face, pointed chin, and brown hair." These excellent descriptions will recall to all of us persons of such builds whom we have known. Moreover, we see these same variations in build among the lower animals, *e. g.*, the greyhound and the bull dog represent the slender and stocky types among dogs, the race horse and the dray horse (Percheron) show the same contrast in body build in horses.

These contrasting types of body build are now a well-recognized biological feature. They are often called the **linear** and **lateral** types,[1] and due allowance has to be made for height, breadth and depth (thickness from front to back) of body in determining whether the weight is enough over or under normal to cause concern. It is normal for the person who inherits long, slender bones and light musculature to have less than average weight, while the broad (lateral) type shows heavier bony framework, relatively more flesh and above average weight.

However, a 10 per cent deduction from the theoretical normal weight for height should be sufficient allowance to cover the slighter body build of the linear type, while a 15 per cent extra allowance should be enough to account for normal heavier framework of the lateral type. Wider variations than these usually indicate less than optimum nutritional status, with conditions undesirable for health.[2]

Sheldon, on the basis of a twenty year study of young men at Chicago and Harvard Universities, has confirmed the existence of variations in body measurements and temperament that fit previous descriptions of the slender and stocky types, and has postulated a third class, the muscular or athletic type.[3] The athletic type may be briefly described as having a square face (contrasting with the round and oval faces of the stocky and slender types), broad square shoulders, heavily developed muscles, an aggressive, insensitive disposition, with love of action and power. The temperament of the slender type is sensitive, shy and introspective, that of the stocky type, comfortable, cordial to people, self-indulgent and averse to physical activity. Sheldon bases his classifications on which of the three layers of the embryo developed predominantly. In the slender type there is predominance of brain and nervous tissues that arise from the outermost layer of the embryo; in the athletic type the predominant development is in body framework and muscles, parts that develop from the middle embryonic layer; in the stocky type the "gut" and other internal organs, which arise from the inner embryonic layer, are preeminent. Of course there are many variations or intermediate grades of body type; pure types are relatively rare and mixed types are common.

It is now well recognized that these types also involve inherited variations from the normal in the size, shape and position of the different parts and organs of the body, which may determine their functioning in such a

[1] Lucas, W. P., and Pryor, H. B., J.A.M.A., v. 97, p. 1127, 1931.

[2] For discussion of disadvantages and dangers of malnutrition and obesity see sections on these topics in Chapters 29 and 30.

[3] Sheldon, W. H., THE VARIETIES OF HUMAN PHYSIQUE and THE VARIETIES OF TEMPERAMENT, Harper and Bros., 1940 and 1942.

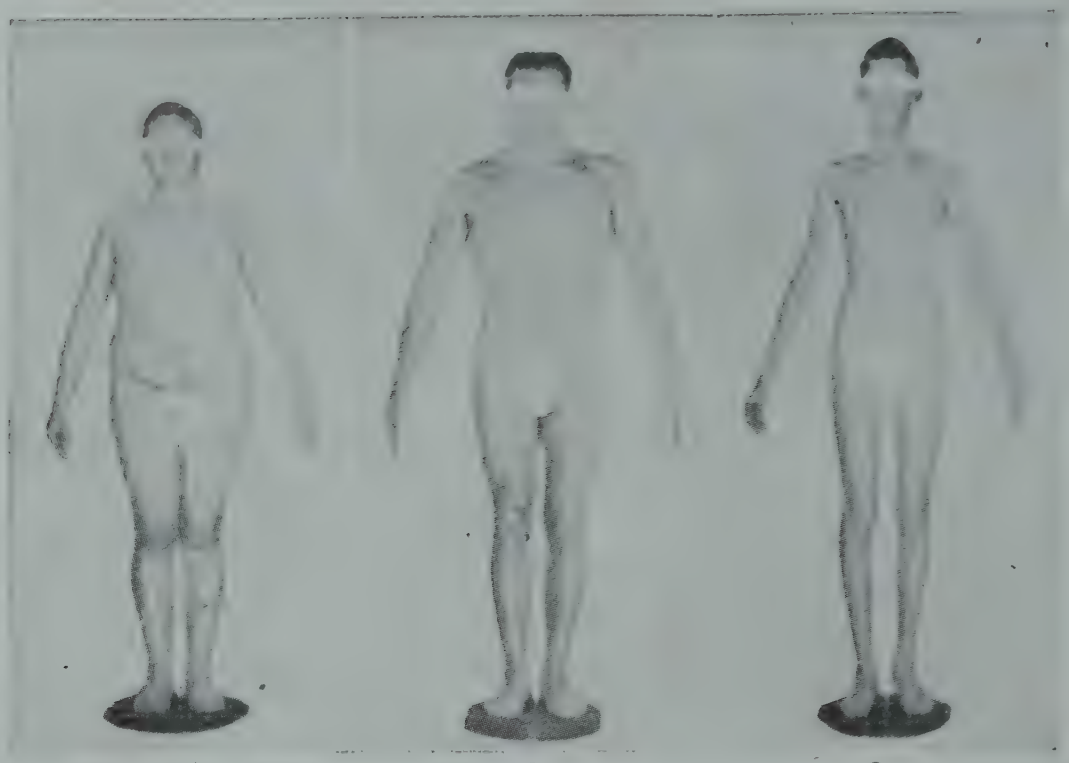


Fig. 51. Front views of the three extremes in type of body build. *A*, Stocky or lateral type. *B*, Muscular or athletic type. *C*, Slender or lineal type. (Sheldon and Stevens: The Varieties of Temperament, 1942, Harper and Brothers.)

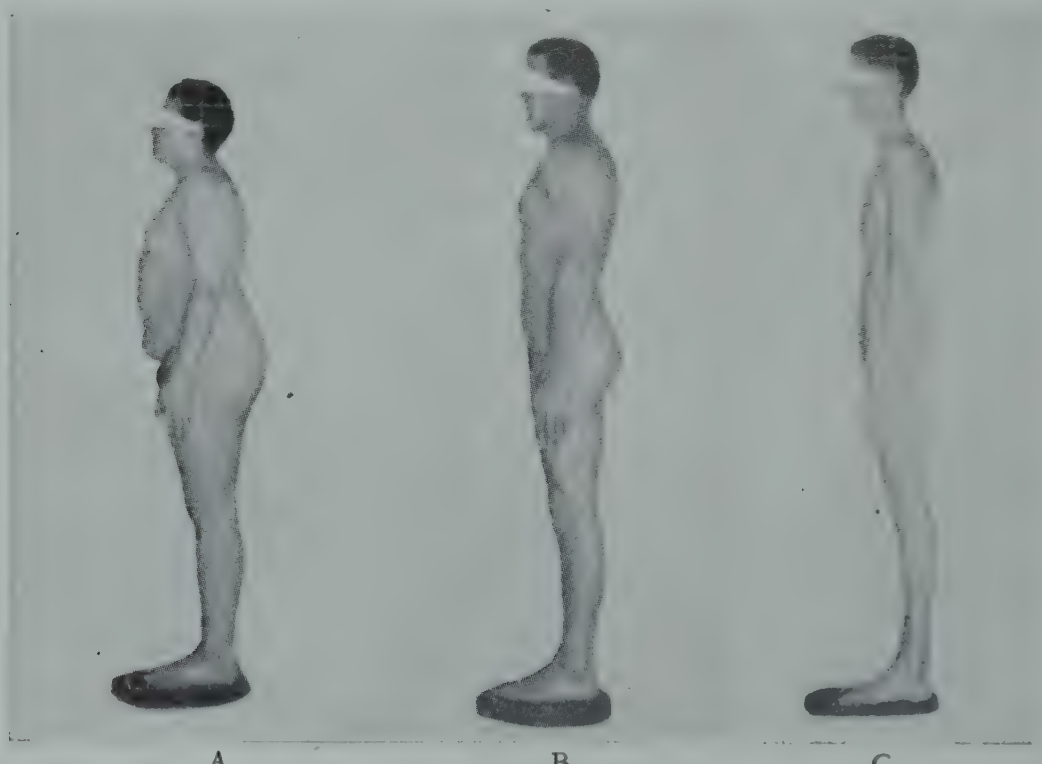


Fig. 52. Side views of the three extremes in type of body build. *A*, Stocky or lateral type. *B*, Muscular or athletic type. *C*, Slender or lineal type. (Sheldon and Stevens: The Varieties of Temperament, 1942, Harper and Brothers.)



Fig. 53. Back views of the three extremes in type of body build. *A*, Stocky or lateral type. *B*, Muscular or athletic type. *C*, Slender or lineal type. (Sheldon and Stevens: The Varieties of Temperament, 1942, Harper and Brothers.)



Fig. 54. An average individual. This is a mid-range physique showing almost an even balancing among the three primary types. (Sheldon and Stevens: The Varieties of Temperament, 1942, Harper and Brothers.)

way as to offer at least partial explanation of the tendencies toward overweight or underweight, and toward certain diseases.[4] Modern "somatic" medicine stresses the necessity of considering the body as a whole in the cure and prevention of disease.

Functional Significance of Body Types. In the **slender type,** the long, narrow, shallow chest cavity and flabby diaphragm make for shallow breathing, poor circulation and less efficient oxygenation of the blood. This in turn may lead to poor nourishment and decreased vitality of the tissues, so that this type is often susceptible to lowered energy and chronic fatigue, colds and other respiratory infections, as well as anemia and nervous indigestion. The digestive tract is muscularly active and the small intestine shorter and more easily irritated than in other types of individual; food passes along more rapidly and assimilation is relatively poor. Hence, it is difficult for such persons to put on weight and they need a **more highly concentrated, nutritious and well-cooked diet.** Persons of slender build are often finicky about food, dislike "roughage," get hungry at shorter intervals but are satisfied with less bulk than other types. They may get on better with four or five small meals than with two or three large ones.

The muscular or **athletic type** has a hearty appetite and usually exercises enough to have fairly high energy needs. Such individuals have steady nerves, good circulation and digestion; they can eat almost any food but usually eat in hurried, businesslike fashion, and may overeat on certain foods, especially meats. Sheldon states that this type is especially prone to develop appendicitis, sinus infection, cancer, infantile paralysis, and sometimes gastric ulcer (seen more frequently in the slender type).

The **stocky type** has a capacious chest, good circulation and aeration of the blood, the "digestion of a billy-goat," and love of eating. The excess weight which they so often accumulate puts extra strain on vital organs and it is common knowledge that this type is particularly subject to high blood pressure, apoplexy, diseases of the heart, kidneys, liver and gallbladder, as well as diabetes. They will put on weight sometimes on a smaller amount of food than suffices to maintain weight in the slender individual. Due to the longer time which the food requires for passage through a long, rather sluggish intestine, the absorption of the digested food elements is unusually complete. The stocky type, therefore, needs a

[4] Thompson, M., "On Anatomical Types and their Relationship to Disease," Canad. M. J., v. 14, p. 1155, 1924; Draper, Geo., *et al.*, "Studies in Human Constitution," J.A.M.A., v. 82, p. 431, 1924 and Am. J. M. Sc., v. 169, p. 322, 1925; Goldthwait, J. E., *et al.*, BODY MECHANICS, Lippincott, 1934; and Sheldon, W. H., THE VARIETIES IN HUMAN PHYSIQUE, Harper and Bros., 1940.

more **bulky diet** and one **not concentrated in its caloric value**, in order to avoid taking on excessive weight.

Physical Defects and Their Nutritional Influence. Such defects have a relation to nutrition only when they interfere in some way with one or more of the body processes that are vital to it. Thus **growths in the nose and throat,** which obstruct BREATHING, are a prominent factor in producing malnutrition, especially in young children when the air passages are smaller, as oxygen from the air is necessary for nutrition of the tissues. Obstructions in the throat may also interfere with SWALLOWING and **tooth defects** may cause the food to be insufficiently CHEWED.

Another frequent cause of the poor physical condition is bacterial inflammation in one or more parts of the body. Such a collection of germs multiplying and producing their toxins at some point in the body is called a **focal infection.** The poisons, and even the bacteria, are absorbed into the blood and exert a markedly harmful influence on the whole body. A MILD, chronic focal infection may not make itself apparent in any way except DECREASED VITALITY and MALNUTRITION, although acute conditions may result in serious diseases. Such infected tissue must be located and treated or removed before the general condition and weight can be built up.

In **childhood,** stunted growth, malnutrition and lowered vitality are often the result of physical defects which can easily be righted and should be attended to. Work with malnourished children and adults has demonstrated the frequent occurrence of remediable defects,[5] about half of which fall in the nasopharyngeal group (obstructions in the nose and throat, diseased tonsils, sinuses, etc.) and decayed teeth are also of common occurrence. It is important that such defects, as well as any others that may be present, be located and treated, since they may not only lead to more serious conditions, but their influence upon the body as a whole makes it impossible for the individual to attain his optimum weight and best condition of health.

Postural Defects and Their Influence on Nutrition. The way the body is used may be as important as the structure of the body itself. By this we mean the more habitual postures in which it is held or carried. The body should be carried so that the center of gravity is well balanced, an erect posture is maintained without undue effort, and muscles are not kept under stress or strain. In action, the posture should be one that makes for

[5] Emerson, W. R. P., NUTRITION AND GROWTH IN CHILDREN, Appleton, New York, 1922, and New England J. Med., v. 202, p. 330, 1930; Roberts, L. J., NUTRITION WORK WITH CHILDREN, University of Chicago Press, 1935.

efficient performance of muscular work with minimum of fatigue. Postural defects that are commonly seen (most frequently in persons of slender build) are (1) head too far forward, (2) chest flat, (3) abdomen relaxed and prominent, (4) back curves exaggerated.[6] Although authorities now allow more leeway in what is considered good postural position, they agree that, for any given individual, the ideal posture should be one that makes for at least moderately good appearance, freedom of action, lack of strain on muscles, ligaments and joints, and proper functioning of the internal organs.

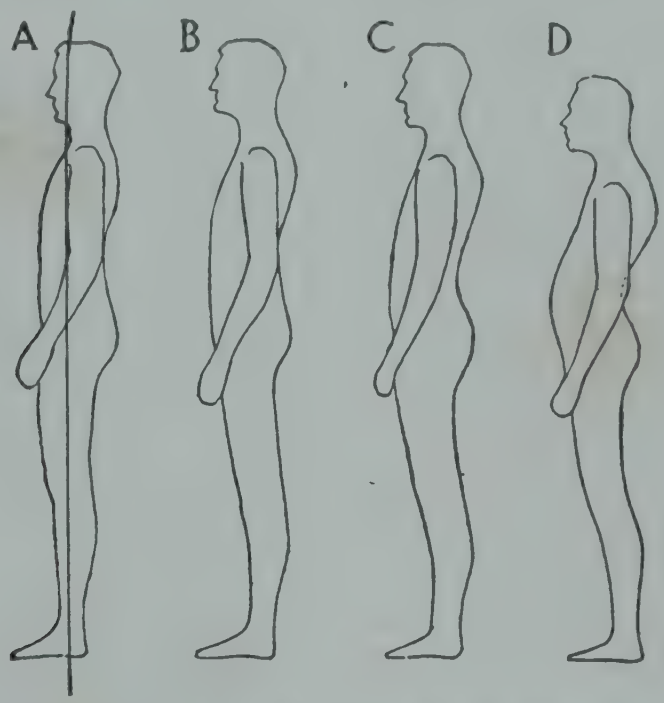
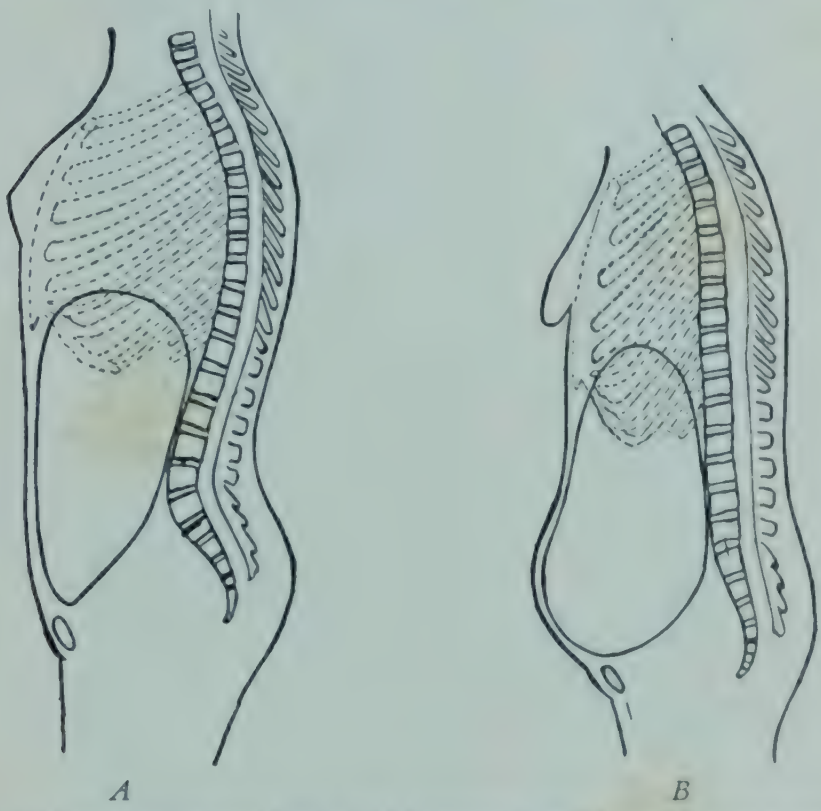


Fig. 55. Distribution of normal young men into groups as to posture: *A*, Good, 7.5 per cent. *B*, Fairly good, 12.5 per cent. *C*, Poor, 55 per cent. *D*, Very bad, 25 per cent. (Courtesy of Dr. Lloyd T. Brown.)

Bad posture may put certain parts of the body under STRAIN or CRAMP them so that the blood supply to them is poor and they are unable to do their work effectively. A deep **chest** of potentially large air capacity may actually produce poorer aeration of the blood, if held in a cramped position and supported by a low and flabby diaphragm muscle so that breathing is shallow, than one of lesser capacity which is used with maximum efficiency. A **stomach** which is capable of doing its job well when in normal

[6] While there are a number of other types of defective posture, it seems best to limit the discussion here to fatigue posture, which is by far the most common type and the one which is directly associated with malnutrition.

position may give constant trouble when it has sagged so far down in the abdomen that its contents must be emptied against gravity or its blood and nerve supply are interfered with. An **intestine** which formerly functioned well may lose the good tone of its muscle wall when there is habitual stagnation of its blood supply, due to its position in the abdomen and to the inactivity of the diaphragm, which is largely responsible for "milking" the



A *B*

Fig. 56. *A*, diagram showing body held in normal position with chest elevated and abdominal cavity shaped like pear with large end uppermost.

B, diagram showing how flat chest and drooping ribs maintained in poor posture assist in forcing viscera down until the shape of the abdominal cavity is the reverse of the normal, smaller at the top. (From Williams, Boston Med. and Surg. Jour., Vol. 172, No. 1.)

blood out of the abdomen back toward the heart by its rhythmic contractions in breathing.

These few illustrations will suffice to point out how it is impossible for an organ to do its work efficiently when held in a disadvantageous position, and are selected because of the evident **influence** of the poor functioning of these particular organs **upon nutrition.** You cannot build up the health of a tubercular person by sending him where there is pure coun-

try air unless you can get that air into the lungs, and you cannot make a sufferer from chronic indigestion put on weight merely by giving him extra food. These illustrations might be multiplied at will, for no tissue or organ can work well and remain healthy when it is habitually placed under



Fig. 57. Illustration showing examples of good and poor posture. (Mrs. McCormick, Dept. of Physical Education, Teachers College, Columbia University.)

such conditions that its blood supply is interfered with or that it is working under strain.

Early instruction of children in correct posture habits and corrective training for postural defects are the necessary means toward doing away with such defects, so that the individual may be kept in or restored to the best nutritive condition.

Overfatigue. After over twenty years of work with underweight children and adults in nutrition classes and clinics, Dr. Emerson makes this statement, "Continued experience in the treatment of malnutrition leads me to the belief that there is no responsible cause for this condition more frequently overlooked than habitual overfatigue."[7] In a large group of **malnourished children** under his observation he found that 64 per cent kept late hours and 54 per cent were suffering from overfatigue due to EXTRA WORK IN CLUBS, CLASSES, or INDUSTRY.[8] The strain of keeping up in SCHOOL WORK and COMPETITIVE GAMES is seldom realized and rest periods are not provided during the day nor sufficient restful sleep insisted upon at night. Music and dancing lessons, as well as other outside activities, are frequently an added strain. Unhappy home conditions sometimes augment nervous fatigue. It is thus difficult, if not impossible, to separate mental and social factors from the problem of overfatigue. Adults do not appreciate how many and wearying are the activities of a child and how much of its energy is required in growth. The child may be overstimulated so as not to realize that its energies are being exhausted, and pride in its achievements may cause the parents to spur on rather than to restrain.

With **adults** the same factors operate to produce fatigue, the most active ones being WORRY and fretfulness, LACK OF REST PERIODS, OVERDOING AT WORK OR PLAY, and inadequate vacations or weekly rest. Again the individual may be sufficiently "keyed-up" not to realize his fatigue or he may have the feeling of being all dragged out but keep on by exertion of will power or by taking some such stimulants as tea and coffee (or stronger ones).

However, in any such discussion we must distinguish clearly between **fatigue,** which is the natural by-product of proper and necessary exertions, and **overfatigue** which means exhaustion—especially **habitual overfatigue,** which carries a person farther and farther from his normal state of health and makes his recovery more difficult.

What is the proof of any direct **relationship between overfatigue and nutrition**? First an overfatigued individual usually experiences a LOSS OF APPETITE or shows a capricousness of appetite and taste in foods, which makes it very difficult to give either sufficient food, a well-balanced diet, or food at the proper intervals and in regulated amounts. Not only is there little desire for food, but what is eaten is apt to disagree. We know beyond a doubt that the ABILITY TO DIGEST and absorb food is LESSENED BY unfavorable nervous conditions—in fact PHYSICAL FATIGUE, as well as NERV-

[7] NUTRITION AND GROWTH IN CHILDREN, Appleton, 1922, p. 80.
[8] Idem, p. 58.

OUS FATIGUE, may cause digestion to be markedly slowed down. This is a matter of common experience, and has been repeatedly proven by scientific experiments (see influence of nervous factors on digestion, p. 328).

But the most convincing proof that overfatigue is a significant influence in nutrition lies in the fact that most overfatigued individuals are **underweight** and persistently refuse to gain until this condition is relieved by extra rest periods. The underweight is accompanied by WEAKNESS, SUSCEPTIBILITY TO INFECTIONS, NERVOUS IRRITABILITY, and other signs that the vitality of the tissues is lowered by their being chronically undernourished.

Increased food intake alone, even if the person can take it without digestive distress, will not build up the nutritive condition satisfactorily in most cases, but when accompanied by relief from the causes of fatigue and increased rest periods, a prompt gain in weight and striking improvement in health and disposition usually follow.

Social and Mental Factors. It is not necessary to go into any discussion of these factors, but they do need to be mentioned, since the fact that happiness has a positive health value, while undesirable mental states lead to many physical ills, is frequently overlooked or underestimated by both physicians and laymen. These factors, when unfavorable, may exert a strong **influence on nutrition** by acting to cause **loss of appetite and weight,** and **disturbed functioning of the digestive organs,** in the same manner as outlined in the paragraph above for fatigue. Favorable effects upon digestion and nutrition will result if good social and mental states can be substituted for the bad. Social forces center about the home, school, business and social life, while mental factors are largely under one's own control. In this day of high-pressure living, conscious effort is often necessary to secure the right relations with oneself and one's fellows. Hence it may not be out of the way to append a list of a few of the most unfavorable factors of this kind, contrasted with their pleasant and beneficial opposites, so that one who desires may check his own tendencies.

Negative.	Positive.
Fear	Confidence
Envy and discontent	Contentment
Strong dislikes	Affections
Hurry	Leisure
Worry	Hopefulness
Irritability	Tranquillity
Self-interest	Interests outside oneself
Self-indulgence	Self-control

Habits. It is generally recognized that habits of living have some influence on health, but probably it is seldom realized how strong this influence may be. In a malnourished individual a number of bad food and health habits are generally to be found by questioning, but sometimes a SINGLE habit unfavorable to health will hold up the return to normal nutritive conditions in a very striking manner. The general health and food habits should be carefully surveyed and good habits substituted for bad, before the undernourished person will be in a position to get maximum profit from an improved diet and thus attain his highest standard of well-being.

The more **common faulty habits,** as found in surveys of food and health habits of both children and college students,[9] are LATE BEDTIME, INSUFFICIENT EXERCISE and OUTDOOR LIFE, IRREGULAR BOWEL MOVEMENTS, use of TEA and COFFEE by children, EATING TOO FAST OR WHEN OVERFATIGUED, and INDULGENCE IN SWEETS between meals. The students who were underweight and those who had frequent colds showed a higher percentage of poor health habits, while a group of students of superior ability had fewer illnesses than the average.

This does not mean that college students generally are in poor health or nutritive condition. Most of those studied were of normal weight (or above), with few ailments except occasional colds, and with excellent appetites—in fact, the majority ate between meals. The present-day college student is both taller and heavier than those of twenty or thirty years ago,[10] and college men are apparently of greater average height than men of the same age group in the population as a whole.[11] Boys 9 to 14 years of age were found to be 6–8 per cent taller and 12–15 per cent heavier than fifty years ago.[12] The probable causes are suggested to be better nutrition in infancy and childhood, fewer communicable diseases, higher living standards, and more widespread information about nutrition and health.

Connection between Weight and Health. The most convincing evidence of the relation of weight to health is the **correlation of overweight and underweight with higher mortality figures** in the statistics gathered by life insurance companies. Tables have been published showing what is the average weight for the various heights, with age and sex also being taken into consideration. (Such tables are given in the Appendix.)

[9] Emerson, W. R. P., "Health Habits in a Woman's College," J.A.M.A., v. 90, p. 1434, 1928; Stearn, E. W., and Mitchell, G. R., "Important Factors in Directing the Health of College Women," Am. J. Pub. Health, v. 21, p. 984, 1931; Chaney, M. S., "Food and Health Habits of Students at Connecticut College," J. Home Econ., v. 30, p. 39, 1938.

[10] Chenoweth, L. B., J.A.M.A., v. 108, p. 354, 1937.

[11] Diehl, H. S., Human Biol., v. 5, p. 445, 1933.

[12] Meredith, H. V., J. Am. Dis. Child,. v. 62, p. 909, 1941.

As these figures have been compiled from groups which include a rather high percentage of underweight children and young adults, and of overweight individuals in the age groups after forty, they do not represent the normal or ideal weights. Adults are advised that the weight at thirty is usually the ideal one to keep in later years, if possible.

In youth a weight slightly in excess of the **average** figures given in the tables (5–15 per cent higher) is considered **advantageous,** as providing a factor of safety to be drawn on in case of need (growth, sickness or temporary food insufficiency) and promoting GREATER NERVOUS STABILITY, INCREASED VITALITY and HIGHER RESISTANCE TO INFECTIOUS DISEASES (tuberculosis, pneumonia, etc.). Life insurance figures have shown that IN THE EARLY TWENTIES MORTALITY INCREASES ABOUT 1 PER CENT FOR EACH POUND **below** AVERAGE WEIGHT for height.

Overweight also is **disadvantageous** for health, **especially in the later years.** The tissues of fat people are not properly nourished so that they are notoriously poor risks in operations and infectious diseases; the excessive weight places an additional burden upon the circulatory system and kidneys, so that such persons are prone to develop functional disorders of the heart, high blood pressure, nephritis, etc. ABOVE THE AGE OF THIRTY-FIVE, MORTALITY INCREASES ABOUT 1 PER CENT FOR EVERY POUND **over** NORMAL WEIGHT for height.

Thus we see that conditions where the nutrition has been badly carried out (underweight and overweight) are directly associated with poor health and lowered vitality. It means a better chance of life and health if one can so adjust his food intake, surroundings and habits of life as to attain and keep himself at the optimum weight for his height.

It is quite possible to maintain an excellent state of nutrition in persons of all types of body build and in almost any environment, but to do SO SPECIAL CONSIDERATION WILL OFTEN NEED TO BE GIVEN TO THE FACTORS OUT-LINED IN THIS CHAPTER. We should recognize the importance of these supplementary factors in nutrition and stress the need of replacing any existing unfavorable factors with those that are favorable for health.

QUESTIONS AND PROBLEMS

1. Check your weight with the average weight for your height and age (see weight tables in Appendix). Compute the per cent deviation from the average as follows: divide the difference between actual and average weights by the average weight and multiply by 100. If of average body build, your weight should closely approach the average for your height, age, and sex. If of slender body build, it should not be more than 10 per

cent below the average; if of stocky build, it should not be more than 15 per cent above the average. If your weight is not what it should be, according to these standards, suggest any reasons for this weight deviation from normal and any changes in diet that may need to be made.

2. Score your general nutritive condition by comparison with the following standards for good nutrition of whole body:

Skin—turgid, smooth, slightly moist, and of healthy color.

Eyes—clear, no dark circles underneath; hair—smooth and lustrous.

Muscles—well developed and firm, not flabby.

Mucous membranes of eyelids and mouth—reddish pink.

Posture, good—head erect, chest up, shoulders flat, abdomen in, body well balanced.

Sleep, appetite, digestion and elimination—good.

Freedom from easy fatigue and susceptibility to infections.

3. Check your food and health habits by noting whether you have any (or how many) of the following faulty habits:

General.	Food.
Irregular bedtime	Irregular mealtimes
Irregular bowel movements	Omitting breakfast
Insufficient exercise and time outdoors	Finicky about food
Insufficient rest periods	Habitual overeating or undereating
Excessive tea, coffee, tobacco, or other stimulants	Fast eating or washing food down
	Eating when overtired
	Eating between meals, especially sweets

4. A young woman, 18 years old, is 12 per cent underweight, has teeth that decay readily and diseased tonsils, is nervous and tires easily, has frequent colds. She has been dieting moderately to keep down weight, avoids fatty foods and takes little bread and butter or milk; likes meat, eggs and fruit, but dislikes vegetables and salads. What measures are needed and what changes in living habits and diet should be recommended in order to increase her weight and build up her general nutritive condition?

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DIGESTION

WHY IT IS NECESSARY. Digestion takes place in a series of organs known collectively as the alimentary tract, and is the **process by which food is prepared for absorption** into the body proper. As eaten, most of the FOOD MATERIALS are in the form of complex substances, which are either INSOLUBLE in water or of such a nature that they CANNOT DIFFUSE THROUGH the membranes that line the digestive organs, and hence cannot be absorbed into the blood.

Moreover, even if they could get through the intestinal lining and into the blood stream, the **tissues could make no use of these complex substances,** since the cells are so constituted that they can oxidize and use for tissue building only a few simple, standard substances. Therefore the complex (and mostly insoluble) FATS, CARBOHYDRATES and PROTEINS must first be completely BROKEN DOWN INTO those SIMPLE COMPOUNDS of which they are made up BEFORE THEY CAN BE ABSORBED and USED. Starch and the more complex sugars, it will be remembered, are all compounds made by linking together simple sugars (p. 12); proteins are complex substances formed by linking together amino acids (p. 44); fats are made by the combination of fatty acids with the simple substance glycerin. The business of digestion is chiefly concerned with breaking down these three classes of foodstuffs into their "building stones," *i. e.*, into simple SUGARS, AMINO ACIDS, FATTY ACIDS and GLYCERIN, which are the **simple,** standardized forms in which **food materials are usable by the tissues.**

How It Is Brought About. The ends to be attained in digestion are brought about by two means:

(1) By **mechanical processes** in which the MUSCULAR apparatus of the digestive tract is employed for REDUCING SOLID FOODS to a finely divided, SEMIFLUID MASS, for MIXING this mass with the digestive fluids and bringing it intimately in contact with the intestinal wall to favor absorption, and for MOVING ALONG the partially digested material from one part of the alimentary tract to another.

(2) By the **chemical action of the digestive juices** secreted by GLANDS located either in the lining of the alimentary tract itself or adjacent and with

ducts emptying into it. The chemical processes constitute the more important part of digestion, although it will be obvious that the proper functioning of the mechanical processes is necessary in order to furnish conditions favorable for the digestive juices to act on the food.

The Alimentary Tract. As suggested above, this will be best understood if considered as organized for its two sets of functions, namely its **muscular** or motor apparatus, and its **glandular** apparatus. The arrangement of the various organs in series (mouth, esophagus, stomach, small intestine, large intestine) is familiar to almost everyone and is shown in the form of a diagram in Fig. 58. It will be noted that this arrangement in series of the digestive organs forms a continuous hollow tube (sometimes called the alimentary canal), with widenings in certain sections (stomach, large intestine or colon) which act as reservoirs where the contents may be held for longer periods.

It should be borne in mind that the digestive tract OPERATES, somewhat like a railway system, BY MEANS OF SIGNALS SENT ON AHEAD from one organ to the next in the series to prepare the way for the oncoming load. Hence, when conditions are such that digestion gets a good start, the later stages go on more easily, while anything that affects the earlier stages of digestion unfavorably will be likely to cause disturbances in the later processes also.

We shall endeavor to describe digestion in such a way as to focus attention upon the FACTORS WHICH MAKE CONDITIONS FAVORABLE OR UNFAVORABLE FOR THE DIGESTIVE PROCESSES, eliminating technical terms for the various parts of the alimentary tract and for the numerous digestive agents (enzymes) contained in the various digestive fluids. This should enable the reader to grasp without confusion what conditions are necessary to safeguard the health of the digestive tract, which is in turn vital to general health and happiness. Brillat-Savarin[1] says, "Digestion is of all bodily functions the one which most affects the moral state of the individual. The manner in which it is habitually performed makes us sad, gay, taciturn, talkative, morose, or melancholy, and we do not suspect the cause."

The **muscular apparatus** concerned in digestion may be briefly described as follows. First there are the muscles of the jaws and tongue which function in the acts of chewing and swallowing, but more important are the muscular coats of the stomach and intestines by which the movements of these organs are carried out. The structure of the walls of the alimentary "canal" is essentially similar throughout its whole length—a so-called

[1] THE PHYSIOLOGY OF TASTE, Brillat-Savarin, 1825. See reference to this author on p. 296.

"MUCOUS MEMBRANE" lining the cavity, two coats of MUSCULAR TISSUE, one consisting of CIRCULAR and one of LONGITUDINAL muscle fibers, and a very thin membrane covering the outside of the tube (see Fig. 64, p. 326). When the circular fibers contract, as they do in small, separate segments, they exert a squeezing motion which presses the contents of the tube closely against its inner wall, churns them about and divides them into

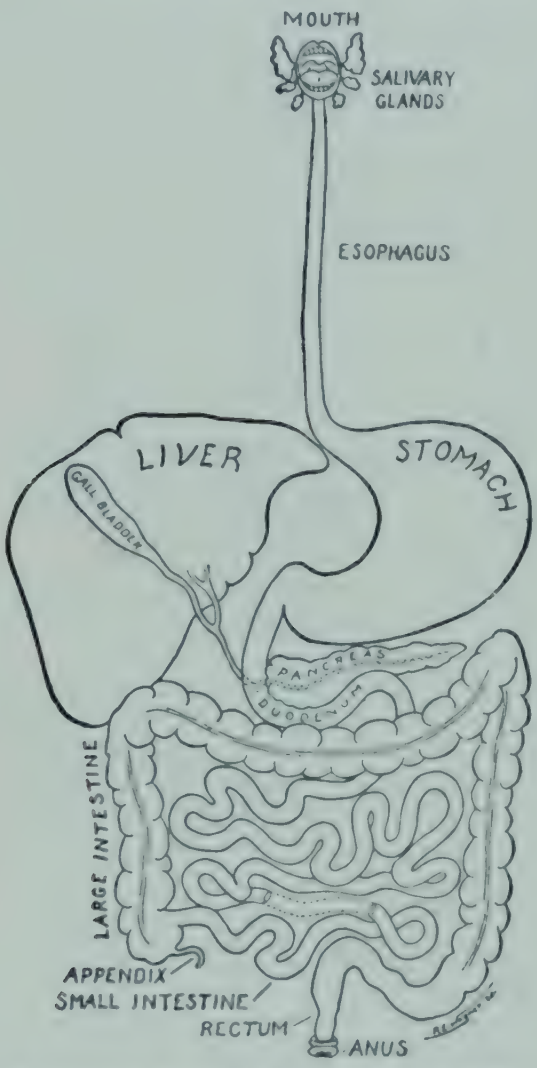


Fig. 58. Diagram of alimentary canal and glands which secrete digestive fluids.

separate segments. When the longitudinal muscle fibers contract, the resulting motion pushes the food mass in one direction or another along the digestive tract. These contractions take place in the form of regular waves that pass along the tube almost always in such a way as to shove the food ahead, *i. e.*, toward the lower end of the tube, the rectum and its outlet, the anus. Such rhythmic, recurring waves of contraction are spoken of as

peristalsis. In a few parts of the alimentary canal these waves of contraction in the muscle coat may travel in the opposite direction, so that they push the food backward in the tube; in this case the term ANTIPERISTALSIS is applied to them. Emotional or digestive upsets may sometimes bring about antiperistaltic waves, resulting in VOMITING. The stomach has a slightly more complex system of muscular coats, in which there are diagonal as well as circular and longitudinal fibers, so that its movements are more varied though similar in general to the movements of the intestines. Active peristaltic waves begin about the middle of the stomach and travel downward. The esophagus and upper part of the stomach have less marked muscular coats and are relatively inactive muscularly.

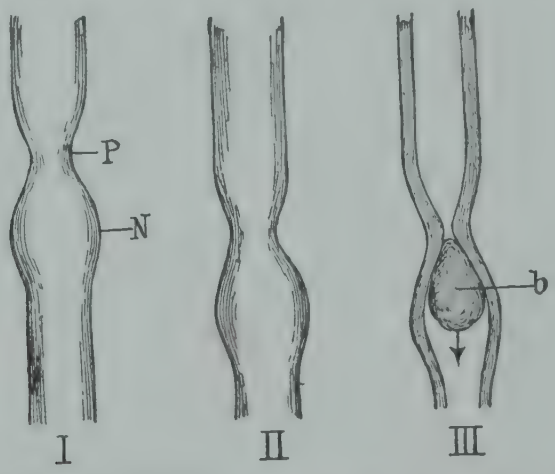


Fig. 59. An exaggerated representation of peristalsis. I and II are successive views of the same portion of the alimentary tube: *P* is the zone of contraction shifting downward and always preceded by the zone of unusual relaxation (*N*). III is an imaginary section through II, showing the food bolus (*b*) slipping along in advance of the contracting region, its advance being facilitated by the relaxation below. (Stiles, "Nutritional Physiology.")

The **glands** which function in secreting the digestive fluids are of two kinds—very small, SIMPLE GLANDS situated IN THE "MUCOSA," or mucous membrane that lines the alimentary tract, and more COMPLEX GLANDS located OUTSIDE THE DIGESTIVE TRACT but which pour their secretions into it through ducts. The structure of all of them is essentially similar and is shown in its simplest form in the diaphragm given in Fig. 60. The lower part of the picture shows the blood supply to the gland, which is essential for bringing to it the materials from which the secreting cells (those lining the pocket-like depression of the gland) manufacture the special substances peculiar to the secretions of that gland. Compound glands are made up of larger numbers of simple glands, bound together with connective tissue and blood vessels, whose individual ducts converge so as to form a sys-

tem of passageways toward the single main duct. The **salivary glands, pancreas** and **liver** are compound glands, which secrete digestive fluids (the SALIVA, PANCREATIC JUICE and BILE) that are discharged into the alimentary tract. **Simple glands, located in the membrane lining the stomach and small intestine,** secrete the digestive fluids known as the GASTRIC JUICE and INTESTINAL JUICE, respectively. Other simple glands, found in the mucous membrane throughout the whole course of the alimentary tract, secrete a slimy substance called MUCUS, which has no digestive

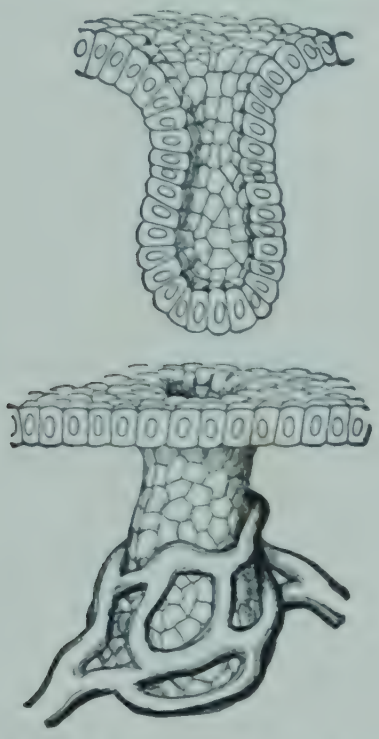


Fig. 60. The principle of glandular structure. In the upper figure a simple microscopic gland is supposed to be laid open by a section along its vertical axis. The cells are seen to surround a recess into which they discharge their secretion. Below, the same structure is shown in its entirety, and in addition the encircling blood-vessels which contribute to make good the losses suffered by the secreting cells. (Stiles, "Nutritional Physiology.")

powers, but serves to lubricate and protect the lining membrane, as well as to give it its name.

Mechanical Processes in Digestion. These will be described somewhat at length as their importance is often underestimated. In the **mouth,** the food is more or less finely divided by CHEWING, and is mixed with saliva and mucus. The SALIVA moistens the food, dissolves certain substances which can then stimulate the sense of taste, and also exerts a chemical action, as will be described below. MUCUS assists the saliva in

lubricating the food for swallowing. The swallowed food mass is carried down the esophagus by a muscular movement, a wave of relaxation preceding the food and a wave of contraction following it (see Fig. 59, p. 314).

The swallowed food passes into the **stomach** and collects largely in the UPPER END, which is muscularly inactive and acts as a RESERVOIR. Gradually, however, this pouch-like portion of the stomach contracts upon itself until the food is moved along into the MIDDLE PART of the stomach, where the glands which SECRETE the GASTRIC JUICE are chiefly located. Gastric juice is STRONGLY ACID with hydrochloric acid. FROM THE MID-PORTION ON, the stomach is MUSCULARLY ACTIVE, and various churning movements mix the food with gastric juice and tend to reduce it to a semifluid mass. At the same time, long, rhythmic, progressive waves force this material toward the lower end, where the opening into the small intestine is kept tightly closed by the contraction of strong circular muscle fibers.

From time to time this circular muscle at the outlet of the stomach, called the PYLORUS, opens and a peristaltic wave sends a gust of the semifluid stomach contents into the first part of the small intestine (duodenum). The opening of the pylorus is conditioned by the consistency of the stomach contents (it tends to let only the more fluid contents pass through), by the relative strength of peristaltic waves in the stomach, by the fullness or emptiness of the duodenum and probably by other factors. As the stomach contents become strongly acid from mixture with gastric juice and are reduced to more fluid consistency, the pylorus opens more frequently and the stomach gradually passes on its contents into the small intestines (see Fig. 61).

As the **stomach** empties, it **contracts upon itself** so that the empty stomach is relatively small, though there usually is a small cavity in it which contains some fluid between meals. After the stomach has been some time empty, rather strong rhythmic contractions set in, which are known as **hunger contractions** and give rise to sensations of hunger that may become distressing. The severity of these contractions depends chiefly on how long the stomach has been empty but somewhat upon its muscular activity, as some people develop hunger contractions more readily than others. Water will stop these contractions temporarily and a "staying" meal, one which does not leave the stomach for some time, is the best preventive for them. FLUIDS LEAVE THE STOMACH relatively QUICKLY; CARBOHYDRATES tend to pass out FASTER THAN PROTEINS, and PROTEINS FASTER THAN FATS; MIXTURES OF PROTEINS AND FATS leave the stomach MORE SLOWLY than either alone.

The **influence of different types of food on the rate at which the stomach empties** serves to explain numerous digestive difficulties. The beneficial effect of including some fat in a meal, when the desire is to have the meal stay by one so as to prevent hunger contractions, has already been noted (page 38). However, acute GASTRIC DISTRESS is sometimes caused by a meal which fails to pass on out of the stomach as it should, and frequently such a disturbing meal will be found to consist largely of fats or of concentrated mixtures of proteins and fats (*e. g.*, pork, cheese, etc.). The HEALTHY STOMACH WILL USUALLY EMPTY IN FROM ONE AND ONE HALF TO SEVEN HOURS, depending upon the quantity and character of the meal taken. The average time for the stomach to discharge an ordinary meal is three to five hours. Meals should not be so close together as to allow no time for the stomach to rest (about 5 hours is usually a good in-

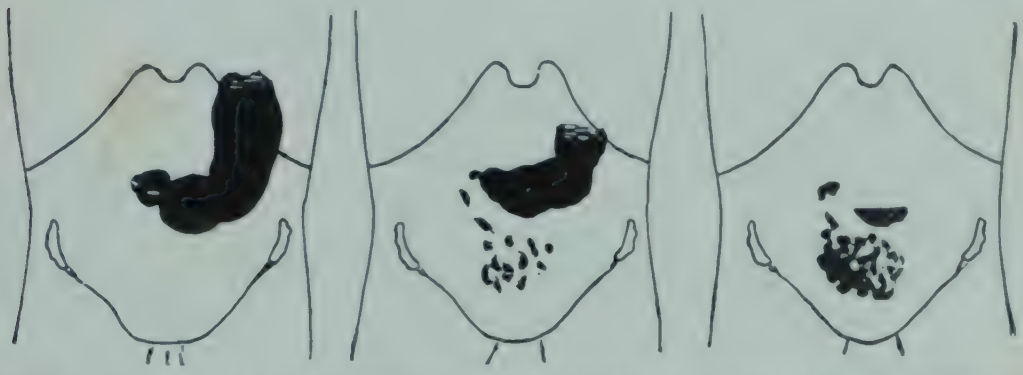


Fig. 61. Shadows of the human stomach obtained with the aid of the Roentgen rays fifteen minutes, one hour, and four hours after the ingestion of the bismuth meal. (Burton-Opitz.)

terval). If one has eaten a very heavy meal that would take extra long to leave the stomach, it might be advisable at the next regular mealtime to take either no food at all or only a small amount of some light nourishment. Naturally it would be better policy to take two moderate-sized meals at the proper intervals.

Food material, which has been passed on from the stomach into the **duodenum,** is allowed to remain there until it is well mixed with the digestive fluids poured in at that point, and is then gradually pushed along into lower portions of the intestine by peristaltic contractions and by further discharges from the stomach.

The largest part of the processes of digestion and absorption takes place in the small intestine, so that it is disadvantageous for food material to be hurried through this portion of the alimentary tract. Active CONTRACTIONS OF THE CIRCULAR MUSCULAR COAT (shown in Fig. 61 by

division of intestine into segments) assist greatly in MIXING the intestinal contents with digestive juices and PROMOTE ABSORPTION. The long, wave-like PERISTALTIC MOVEMENTS are responsible for PASSING MATERIAL ALONG THE INTESTINE, and the rate at which this is accomplished depends largely upon how active the intestine is muscularly.

Needless to say the **movements of the stomach and intestines** are not under voluntary control but they are **influenced by** many factors, chiefly by the GENERAL NUTRITIVE CONDITION of their own muscular tissues and by various NERVOUS FACTORS, which will be discussed later. IRRITATING SUBSTANCES within the intestine will stimulate peristalsis, and are the usual cause of DIARRHEA, a condition in which the food residues are passed through the intestines so quickly that they are excreted in a fluid state. Some CATHARTICS also act by stimulating peristaltic movements.



Fig. 62. Shadows of the human large intestine obtained I and II at later intervals after the bismuth meal, and III by injecting a solution of bismuth salt through the rectum. (Burton-Opitz.)

The lower portion of the intestinal tube, known as the **large intestine** because its diameter is about twice that of the upper portion, is SHORTER and considerably LESS ACTIVE MUSCULARLY than the small intestine. A valve separates these two portions of the intestine and ordinarily prevents material which has been discharged from the small intestine from being forced back into it by the movements of the large intestine, or COLON. The small intestine lies in the abdominal cavity in an irregular mass of coils, but the shorter colon takes a regular and peculiar position (see *x*-ray pictures in Fig. 62), first ASCENDING, then CROSSING the abdominal cavity from side to side at about the level of the lower part of the stomach, then DESCENDING in the rear of the cavity to empty into the RECTUM, which opens to the exterior through the ANUS, an opening guarded by a double ring of circular muscle fibers.

The fact that the intestinal contents must travel part of the way against gravity and pass a number of sharp "kinks," along with the lesser muscular activity of the large intestine, makes for **slow progress** of material **through the colon.** In addition an important feature of the movements of the colon is that above the middle of the transverse part **antiperistaltic waves** are fairly common, which serves to push the contents backward and to delay their passage out of this section of the colon still further. This allows time for any digestion and absorption which has not been completed in the small intestine to go on to completion, though the foodstuffs are generally presumed to be ABOUT 85 PER CENT DIGESTED AND ABSORBED BY THE TIME THEY REACH THE LARGE INTESTINE. No digestive enzymes are secreted into the colon, so that any digestion carried on there is due to the action of enzymes that were mixed with food higher up in the alimentary tract, or to the action of intestinal bacteria. **Considerable water is absorbed** from the large intestine so that the food residues, which enter the colon in semifluid form, become more solid, and may be too hard and dry for easy passage if they remain too long.

Beyond a moderate delaying in the upper part of the colon, comparative **stagnation of material in the large intestine,** such as can easily happen, is of no benefit and may be very **disadvantageous.** CONDITIONS FOR BACTERIA TO MULTIPLY and to act upon food material are usually unfavorable in the stomach, more favorable in the small intestine, and MOST FAVORABLE IN THE LARGE INTESTINE. The products of bacterial action are GASES that may be distressing, ACIDS that may irritate the intestine, and PUTREFACTIVE SUBSTANCES that may be absorbed and be injurious to the body as a whole. Hence the MUSCULAR ACTIVITY OF THE COLON is very important in maintaining INTESTINAL HYGIENE, and anything which tends to favor moderately rapid passage of food through this section of the alimentary tract is generally a beneficial factor.

Chemical Processes in Digestion. These are the processes by which the **foodstuffs** are actually **broken down** in preparation for their **absorption and use by the tissues** (see p. 311). Hence they really **constitute digestion** in the narrower and more correct use of the term. Important as these chemical processes are, however, we shall be able to go into them less fully than the mechanical factors, which are essential only in so far as to provide suitable conditions for the chemical factors to act. In order to explain and discuss these chemical processes at all adequately, a larger knowledge of chemistry would be necessary than we are presupposing our readers to have. It is to be hoped that readers will realize that the brief and simplified description of the chemistry of digestion, which we are obliged

to give under these circumstances, is necessarily incomplete in many details, and that this brevity will not lead them to minimize the relative importance of these factors.

Digestion takes place through a **cleavage** of the complex food materials into their **simplest component parts** or "building stones." In the case of very COMPLEX SUBSTANCES like the proteins and starch, this chemical breaking down takes place GRADUALLY, so that a good many INTERMEDIATE COMPOUNDS are formed in the process of digestion before the original

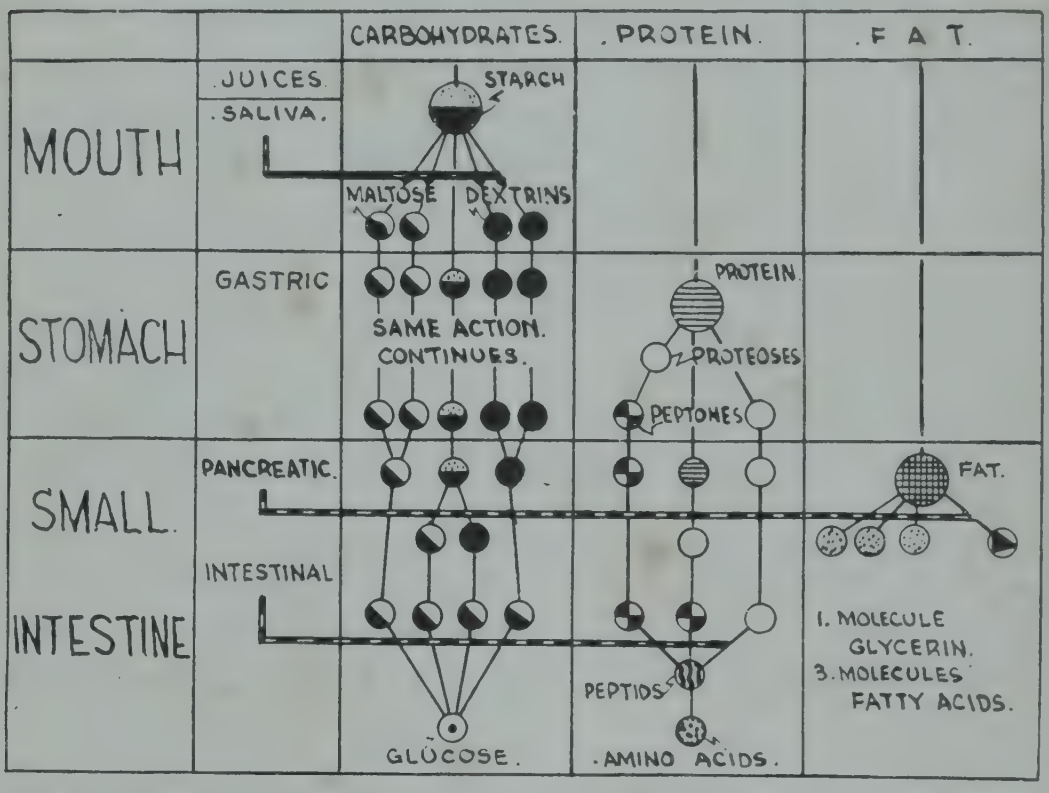


Fig. 63. Diagram to show chemical steps in the digestion of starch, protein and fat. At each stage of digestion of starch or protein, larger molecules are split into too many smaller molecules to be indicated quantitatively in the diagram.

material is reduced to its simplest components. These intermediate products become increasingly simple as digestion progresses, until eventually **starch** is completely broken down into the simple sugar, **glucose,** and the "chemical mosaics" called **proteins** are reduced to those **amino acid** fragments from which they were built (see diagram in Fig. 63).

Less complex substances like **fats** and the double **sugars** (cane sugar, milk sugar and malt sugar) are broken up at a SINGLE step into their components—**fatty acids** and **glycerin,** and the **simple sugars,** respectively. The simplest constituents of the diet do not need to be broken down by

digestion. This is true of simple sugars, mineral salts, meat extractives, alcohol and water, which are absorbed in the form in which they are consumed.

The gradual chemical break-down of proteins and of starch through various intermediate stages until they are finally reduced to their simplest "building stones," and the simpler cleavage of fats and double sugars into their components during digestion, are summarized below. It should be understood that the arrow, in each instance, represents the splitting of a larger molecule into a number of (in some cases very many) smaller ones by means of a chemical reaction with water—a process known as hydrolysis.

Proteins → { acid proteins / alkali proteins } → proteoses → peptones → peptids → amino acids
Starch → dextrins → maltose → glucose
Fats → fatty acids and glycerin
Maltose (malt sugar) → glucose and glucose
Sucrose (cane sugar) → glucose and fructose } simple sugars
Lactose (milk sugar) → glucose and galactose

These chemical cleavages which constitute digestion are **brought about through** the agency of substances called **enzymes.** The same chemical changes will take place if proteins, starch, fats, or double sugars are subjected to prolonged heating with water and acid or alkali in the laboratory. The acid or alkali act as "catalysts" that is, agents that speed up the chemical change merely by their presence. In the body, digestive enzymes bring about these chemical changes more rapidly and at lower temperatures than other catalysts mentioned above. They do not themselves take part in the chemical processes by which foodstuffs are broken down but their presence facilitates or hastens these processes, as if the removal of some hindrance enabled them to take place readily. Enzymes are catalysts that are **formed by living cells** and the DIGESTIVE ENZYMES are formed by the secreting cells of the DIGESTIVE GLANDS, those glands which secrete fluids into the alimentary tract (p. 315).

Enzymes are said to be **specific,** that is **each one acts upon only a certain class of foodstuffs.** When a digestive fluid has the ability to digest two or more kinds of foodstuffs, there is evidence sufficient to cause us to believe that there are separate and distinct enzymes in it for the performance of each of these chemical tasks. In other words, there are PROTEIN-SPLITTING enzymes, FAT-SPLITTING enzymes, STARCH-SPLITTING enzymes, and SUGAR-SPLITTING enzymes, each type acting upon only one kind of foodstuff.

Nor are the **enzymes in different digestive juices,** which act upon the same kind of food, identical. We know this because they **require different working conditions.** The STARCH-SPLITTING ENZYME IN SALIVA will act only when the containing fluid is NEUTRAL or SLIGHTLY ALKALINE; but the enzyme in the pancreatic juice, which digests starch, is not so unfavorably affected by a faintly acid reaction. The PROTEIN-SPLITTING ENZYME IN THE GASTRIC JUICE requires quite a high degree of ACIDITY to be effective, while there is a protein-splitting enzyme in the pancreatic juice which works in a slightly acid, or even in an alkaline medium.

Enzymes, when they have been separated in purified form, seem to be proteins or protein-like substances and there is every reason to believe that they are formed in the body from amino acids distributed to cells by the blood.[2] It is noteworthy that their enzyme activity is lost if they are exposed to any chemical that renders protein insoluble, as well as by boiling which produces the same effect. All enzymes are SENSITIVE TO HEAT AND COLD. They are destroyed by boiling temperatures and their activity is suspended by cold. The DIGESTIVE ENZYMES all seem to WORK BEST at about the TEMPERATURE OF THE BODY.

A simplified **list of the different enzymes found in the digestive fluids** is appended, omitting the individual names for the various enzymes because they are of no special significance in the story of digestion.

Digestive Enzymes

Saliva contains a STARCH-SPLITTING enzyme.

Gastric juice contains a PROTEIN-SPLITTING enzyme, a FAT-SPLITTING enzyme, and the enzyme which causes milk to curdle or CO-AGULATE in the stomach.

Pancreatic juice contains a PROTEIN-SPLITTING enzyme,
a STARCH-SPLITTING enzyme,
a FAT-SPLITTING enzyme.

Intestinal juice contains a PROTEIN-SPLITTING enzyme and
THREE SUGAR-SPLITTING enzymes.

Bile does not contain any enzymes but FACILITATES the DIGESTION and ABSORPTION of FATS.

[2] There are innumerable enzymes, besides digestive enzymes, formed in body cells, and they bring about many types of chemical changes. Enzymes are also formed in living plant cells. Since they are catalysts and hence not used up in the reaction that they bring about, a small amount of an enzyme is needed to act on large amounts of substances. Purified preparations of digestive enzymes have been found to bring about the digestion of several million times their own weight of a given foodstuff and to be active even in very high dilution.

Secretion of Digestive Fluids. It is important to have a clear idea of the **factors which stimulate** and **factors which inhibit** (slow down) the secretion of the digestive fluids. The saliva, gastric juice and bile are secreted in small amounts all the time, but their flow is greatly ACCELERATED WHEN FOOD IS PRESENT to be acted upon. The pancreatic juice (secreted by the pancreas) and intestinal juice (secreted by small glands in the intestinal lining) are formed only under the stimulus of the presence of food material in the intestine. The secretion of the SALIVA and GASTRIC JUICE is largely CONTROLLED BY NERVOUS IMPULSES, but the flow of the DIGESTIVE FLUIDS used in the LOWER PART of the alimentary tract is relatively free from nervous control and is STIMULATED BY OTHER MEANS.

It is in the various mechanisms for stimulating and inhibiting the flow of digestive juices that we find the most striking instances of how signals are sent on ahead from one part of the alimentary tract to the next to get ready for the coming task, and of how **conditions in one part** accordingly have a marked **influence upon digestion in the next part.** The presence of food in the mouth, through the sense of TASTE and the mechanical stimuli of CHEWING, stimulates the flow of SALIVA and also **starts the secretion of the gastric juice in the stomach.** Hence, thorough chewing is an aid to digestion by causing a good flow of digestive fluids, as well as by dividing the food into small pieces and mixing it well with the saliva. It also gives needed exercise to the teeth and gums, and makes one content with a smaller amount of food. Hurried eating and bolting the food in lumps is a good way to court digestive difficulties.

The flow of SALIVA and of GASTRIC JUICE is also stimulated (though to a lesser degree) by the SIGHT, SMELL, or even by the THOUGHT of food. This is called **psychic secretion** and is familiar in the traditional "watering of the mouth" at the odors or thoughts of appetizing food. **Appetite,** which is the desire or relish for food, is a factor which makes for good secretion of digestive juices, and thus for good digestion. Appetite is a psychic factor and should be distinguished from HUNGER, which is caused by contractions of the empty stomach and, when severe, may leave the stomach rather enfeebled for doing its duty. APPETITE is influenced in turn, either favorably or unfavorably, by one's STATE OF MIND, COMPANY, and TABLE SURROUNDINGS, as well as by the ATTRACTIVENESS OF THE FOOD, and thus all these factors have an influence upon digestion.

It is well known that FEAR, ANGER, WORRY, IRRITATION, STRONG EMOTION and FATIGUE all exert a decided **influence in inhibiting** the secretion of SALIVA, but it is less well recognized that they have a similar effect in suppressing the flow of GASTRIC JUICE. The dryness of mouth experienced

in "stage fright" and other types of fear is a familiar phenomenon. Such mental and emotional states exert a strong unfavorable influence on digestion not only by inhibiting the flow of digestive fluids but also by SLOWING DOWN THE MUSCULAR MOVEMENTS OF THE ALIMENTARY TRACT. The apprehensive semi-invalid thus actually induces "nervous indigestion" by his introspective state of mind and by the certainty that various foods will disagree with him.

When food has passed from the mouth to the stomach, while nervous and psychic factors still exert a decided influence, other factors come into play. While the stomach may be made to "water" in preparation for receiving food by the presence of food in the mouth or by psychic influences which favor the secretion of digestive fluids, the **presence of food in the stomach** itself is a still stronger **stimulus to the flow of the gastric juice.** Some foods call forth a more copious secretion of gastric juice than others. Meats and meat extractives (as in soups made from meat) are thought to have an especially stimulating effect on gastric secretion; water also promotes the flow of gastric juice.

Good digestion in the stomach exerts a favorable influence upon digestion in the intestine in that, when there has been a LIBERAL FLOW OF GASTRIC JUICE, the extra acidity thus caused in the stomach contents as they are ejected into the intestine, acts to STIMULATE a more copious flow of all the DIGESTIVE FLUIDS that are NEEDED FOR INTESTINAL DIGESTION.

The **secretion of the pancreatic juice, bile and intestinal juice is not affected by nervous factors,** except as they exert an influence indirectly through affecting the blood supply to the organs concerned or through sympathetic disturbances set up as the result of poor digestion in the stomach. It is a considerable "factor of safety" in nutrition that even when a good deal of distress is experienced because digestion in the stomach is poor, the LATER STAGES OF DIGESTION ARE LIKELY TO BE CARRIED OUT EFFICIENTLY AND THOROUGHLY.

The **chief stimulus** to the secretion of the **pancreatic juice** and **bile** seems to be through the presence in the **duodenum** (first part of small intestine) of **food material impregnated with acid.** This starts a copious flow of pancreatic juice and bile, and causes the bile which has been stored in the gallbladder to be poured into the duodenum. These two fluids enter through a common duct a few inches below the outlet from the stomach (see Fig. 58, p. 313). The presence of FOOD MATERIAL IN ONE SECTION OF THE INTESTINE acts as a stimulus to the SECRETION OF INTESTINAL JUICE IN THE SEGMENT IMMEDIATELY FOLLOWING. Thus the system of "signaling ahead" holds good in the lower, as well as in the upper, portion of the digestive tract.

Summary of Digestion

In Mouth and Stomach. Food is minced by chewing and mixed with SALIVA in the mouth, then passed into the muscularly inactive upper portion of the stomach, where it may lie for half an hour or more before it is mixed with gastric juice. During this interval the starch-splitting enzyme in the saliva, which had scant time to act in the mouth, CARRIES ON THE DIGESTION OF STARCH. When the stomach contents are mixed with the acid gastric juice in the middle portion of the stomach, salivary digestion is stopped and gastric digestion begins. The strongly acid GASTRIC JUICE STARTS THE DIGESTION OF PROTEINS and of very finely divided (emulsified) fats by the action of the enzymes which it contains. It also COAGULATES MILK, *i. e.*, causes it to turn from a liquid to a solid so that it does not leave the stomach too quickly. Heat-treated or homogenized cow's milk and human milk form a finer, more easily digested curd than raw cow's milk (see Fig. 10, p. 71).

In Intestines. After food material reaches the DOUDENUM, it is mixed with PANCREATIC JUICE, BILE and INTESTINAL JUICE, all of which are alkaline in reaction and neutralize the acidity produced by the gastric juice. The DIGESTION OF PROTEINS IS CARRIED TO COMPLETION by enzymes secreted in the pancreatic and intestinal juices; FATS ARE DIGESTED by an enzyme in pancreatic juice, and the bile assists indirectly in fat digestion, though it contains no enzymes. STARCH DIGESTION, begun by the saliva, IS CARRIED ON FURTHER by an enzyme in pancreatic juice, and the DOUBLE SUGARS ARE SPLIT TO SIMPLE SUGARS by enzymes in the intestinal juice. Thus the THREE FOODSTUFFS are REDUCED COMPLETELY TO THEIR SIMPLEST COMPONENTS (amino acids, simple sugars, and fatty acids and glycerin) by the progressive action of the enzymes in the digestive fluids, and are READY FOR ABSORPTION.

The HIGH DEGREE OF EFFICIENCY IN DIGESTION is made possible by the fact that there are at least two enzymes which act on each of the foodstuffs, so that if food is not attacked or is only partially digested in the earlier stages of the process (*e. g.*, in the stomach), there is little chance that it will not be acted upon by the enzymes contained in the digestive juices secreted farther on in the alimentary tract.

ABSORPTION

This is the process by which the **products of digestion** pass through the lining of the intestine **into the blood** and lymph.[3] Simple sugars and

[3] Lymph is a straw-colored fluid that is the middle-man between the blood and the tissues, since the blood is enclosed in blood vessels and does not come directly in contact with the tissue cells.

amino acids are absorbed DIRECTLY into the blood stream; fatty acids and glycerin are recombined in tiny fat globules in the intestinal membrane, and pass into the LYMPH, which is collected through tiny lymph vessels and finally emptied into the blood.

Of all these products of digestion, only the **fatty acids** are NOT SOLUBLE IN WATER, and it is because BILE RENDERS FATTY ACIDS MORE SOLUBLE, that it is essential to their absorption, as well as to the absorption of the fat-soluble vitamins. The bile also promotes the digestion of fats by aiding in their emulsification, that is, their division into finer particles so that di-

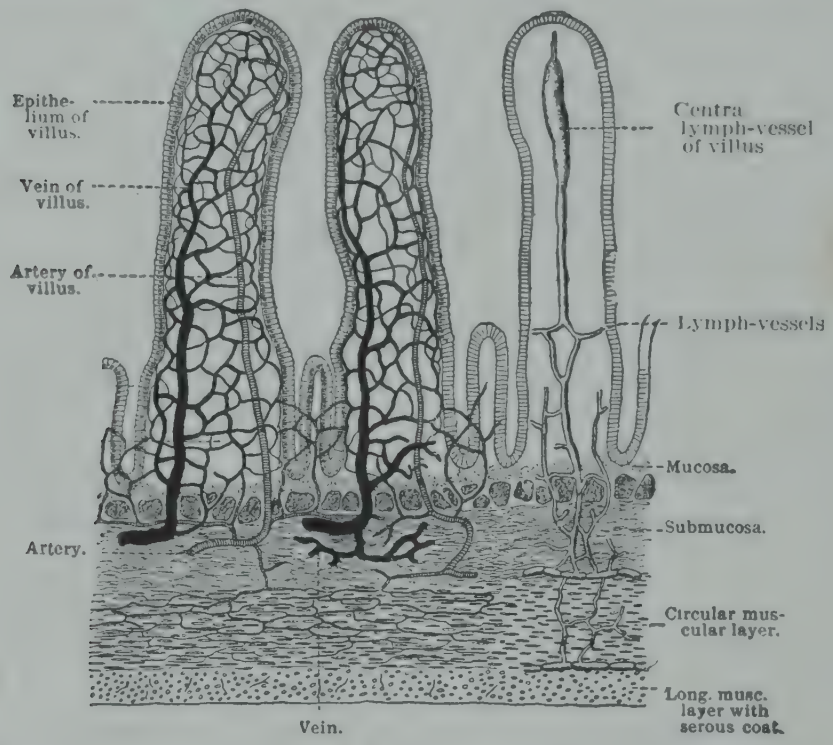


Fig. 64. Diagram of cross-section of the human small intestine, showing projecting villi containing blood and lymph vessels for absorption of food. In the lower portion of the picture are seen the layers of circular and longitudinal muscles useful in the movements of the intestine. (Modified from F. P. Mall.)

gestive juices have greater contact with the fat. When bile is prevented from emptying into the alimentary tract, as in obstructive jaundice, the clay-colored stools give evidence of the resultant poor fat absorption. Since bile also tends to keep down putrefactive processes in the intestine, stools are foul smelling in its absence.

The WATER-SOLUBLE products of digestion, **sugars** and **amino acids** (as well as water-soluble vitamins and mineral salts, meat extractives, and water itself), pass readily through the intestinal membrane into the blood stream. A good deal of water is absorbed from the large intestine.

The **absorption** of food material, however, **takes place almost entirely in the small intestine** and is favored by the fact that the inner surface of this part of the digestive tract is much increased by being thrown up into tiny projections called **villi** (see Fig. 64, p. 326). Each of these villi contains numerous small BLOOD VESSELS and a LYMPH SPACE, so that both the blood and lymph are brought very close to the intestinal membrane and the absorption of material from the intestinal contents is thus made easy. The muscular contractions of the intestine also serve to bring its contents into close contact with its wall and to "milk" blood and lymph into and out of the villi. Because the breaking down of foodstuffs in digestion takes place gradually and the products of digestion are absorbed as they are formed, the body is not overwhelmed with a great surplus of newly absorbed food material at one time.[4]

Anything which makes for MORE INTIMATE CONTACT of the intestinal contents with the lining membrane, or for SLOWER PASSAGE OF FOOD through the small intestine, will FAVOR MORE COMPLETE ABSORPTION; INCOMPLETE ABSORPTION may be the result of an irritated, highly MOTILE INTESTINE which hurries food through too rapidly, of the FORMATION OF INSOLUBLE COMPOUNDS in the intestine, or, in the case of fat absorption, from LACK OF BILE. Absorption is usually very efficient and COMPLETE; most of the **foodstuffs are 90–98 per cent digested and absorbed** on a mixed diet and under normal conditions.

CONDITIONS WHICH AFFECT DIGESTION

Under this heading we shall endeavor to summarize and discuss the practical applications of those **factors which make** either **for efficient functioning** and good health of the digestive organs, or for **digestive distress** and **functional disorders** of the alimentary tract. As digestive complaints are very common, evidently securing the best conditions for the working of the digestive organs is none too easy. While these organs can stand a good deal of abuse without showing immediate effects, trouble usually comes sooner or later, if they are compelled to go on working under difficult conditions. A healthy person never realizes that he has a stomach or intestines. These organs perform their functions best when we treat them with consideration, but regard eating neither as an occasion for indulgence nor as a necessary bore. Proper regard for the digestive tract will enable one to forget its existence and, in addition, good digestion will

[4] This is one of the reasons why it is better to take carbohydrate in the form of starch, which is gradually digested, than as sugar, which is much more quickly absorbed, so is liable to flood the system with a surplus of sugar and may even result in the excretion of sugar in the urine when taken in large amounts.

promote general health and optimism. It is notable that all the great pessimistic philosophers have been dyspeptics.

The various factors which affect digestion may be grouped as follows:

(1) Nervous factors.
(2) General nutritive factors.
(3) Structural and postural factors.
(4) Food factors.

They all act either **by affecting the motor functions** of the digestive organs or **by exerting an influence on the flow of the digestive juices.** Different conditions will exert a favorable or unfavorable influence upon digestion, according as they have a stimulating or inhibiting action.

1. Nervous Factors. These are put first because they are probably of greater relative importance than the other groups. FEAR or WORRY, ANGER or IRRITATION, NERVOUS FATIGUE or STRAIN, EMOTION or EXCITEMENT all exert a strongly **unfavorable** influence upon digestion (especially in the stomach), both by suppressing the flow of digestive fluids and by inhibiting the muscular activity of the alimentary tract. The latter effect is well illustrated by Dr. Cannon's[5] experiment of showing a puppy to a cat, whose digestive processes he was following by means of the *x*-ray. Digestion, which progressed normally at first, was inhibited for about FOUR HOURS after the excitement incident to the sight of the dog. Such conditions as introspection or CONCERN ABOUT ONE'S SELF, monotony or BOREDOM, MENTAL PREOCCUPATION or OVERSTIMULATION have similar unfavorable effects and are often associated with LACK OF APPETITE, which in itself constitutes an unfavorable factor.

The reverse conditions exert a **beneficial** influence on digestion through promoting good secretion of digestive fluids and proper muscular activity of the alimentary tract. Peace and QUIET, cheerful but not over-stimulating COMPANIONSHIP, APPETIZING FOOD, with ATTRACTIVE SURROUNDINGS AND TABLE SERVICE, all are factors that favor good digestion.

2. General Nutritive Factors. It is a little difficult to show the direct influence of these upon digestion, but they need to be mentioned because it is well recognized that the "RUN-DOWN" CONDITION WHICH RESULTS FROM INDIGESTION, with consequent poor utilization of food, eating small amounts, and eliminating many foods from the diet, constitutes a "vicious cycle" which results in still greater inability of the digestive organs to meet their tasks. The nervous individual who has developed fixed ideas that a number of foods are sure to disagree with him, is almost certain to take a

[5] W. B. Cannon, formerly Professor of Physiology at Harvard Medical School.

very RESTRICTED OR ONE-SIDED DIET. Such a diet is often poor in fruits, vegetables, whole grain cereals or milk, and hence low in vitamin content and mineral elements. LACK OF VITAMIN B_1 is especially likely to be associated with lack of appetite and poor muscular tone of stomach and intestines; poor nutritive condition of the mucous membrane that lines the alimentary tract may be caused by LACK OF VITAMINS A, C, OR THE B-COMPLEX VITAMINS. The fact is that a person who is in **poor general nutritive condition** from whatever cause this may result, is extremely likely to show the effects of this condition in a **poorly functioning alimentary tract.**

3. **Structural and Postural Factors.** These are factors whose influence on digestion is frequently overlooked. Usually it is merely a matter of adjusting postural defects with a view to allowing organs to function to somewhat better advantage, but if abnormalities in these respects are great, they may lead to severe digestive difficulties. A stomach which is so badly out of position that it cannot empty properly will not only give immediate distress signals, but the continual irritation that results may eventually cause gastric ulcers or even cancer of the stomach. The poor blood supply to the intestines, which results when they are crowded down into disadvantageous positions in the abdomen, causes the muscular walls of the intestines to become flabby and is one of the contributory factors in constipation.

4. **Food Factors.** These are the factors to which the lay mind attributes most of the ills of digestion but they are less important than usually supposed. The HEALTHY stomach and intestines will **digest almost any ordinary food or combination of foods** without trouble. This does not mean, however, that they will handle any QUANTITY of food or any COMBINATION OF FOODS DIFFICULT TO DIGEST without rebelling, and habitual abuse of them in these respects will undoubtedly lead to digestive disorders. The reason many persons experience digestive distress when they eat foods or combinations of foods, which they believe will give them trouble, is that the CONVICTION OF and APPREHENSION OF HARM to come is sufficient in itself to CAUSE THE POOR DIGESTION which follows. Moreover, the **distress** felt is practically always **due to poor gastric digestion** or failure of the stomach to empty promptly, and the offending foods are usually WELL DIGESTED AND ABSORBED LATER ON IN THE INTESTINES.

A few people are unquestionably sensitive to certain foods and are made ill by them, but such **food sensitization or allergy**[6] is not very common and needs to be confirmed by the tests of a physician.

If the psychic factor could be removed, most people would find that they

[6] For fuller description of food sensitization or food allergy see pp. 426–427.

could digest MODERATE amounts of almost any food with ease, always PROVIDED OTHER CONDITIONS WERE FAVORABLE for good digestion. Probably it is safe to say that 90 per cent of the **digestive distress,** which is **attributed to** the kind or combinations of **food eaten** is **due rather to conditions unfavorable for digestion**—such as mental or emotional states, to eating when overfatigued, to taking too large a quantity of food, or eating at one meal too many foods which are difficult to digest.

All that has been said in the above paragraph only indicates that there is nothing INHERENT in certain foods which makes them indigestible in the sense that they are SURE TO CAUSE DIGESTIVE DISTRESS, although they may cause it, of course, if unwisely used. The digestion of some foods undoubtedly involves more effort on the part of the digestive organs than does that of others. Such foods are said to be **hard to digest** while others are relatively **easy to digest.** In general, LIQUID foods, FINELY DIVIDED or SOFT foods, and hard foods like dry toast or crackers, which must be well chewed, are those most easily handled by the digestive tract, FATS and FOODS RICH IN FATS (especially mixtures of proteins with fats), foods which are introduced into the stomach in LARGE PIECES (and especially in chunks coated with fat), protein-rich foods which have been made TOUGH IN TEXTURE by overcooking, and foods in which the CELLULOSE FIBER has not been softened by long enough cooking, are those which it is something of a tax upon the alimentary tract to handle. Many foods are intermediate between these two groups in the relative ease with which they are digested.

Naturally, it is only the part of discretion to take only **small amounts** of the **easily digested foods** when one is OVERFATIGUED, after a DIGESTIVE UPSET or other ILLNESS where the digestive powers are weakened, or **when conditions** are otherwise **unfavorable for digestion.** This is the reason for the fluid and soft diets given to INVALIDS and convalescents, when smaller amounts of food are usually given at shorter intervals. It is also the basis of diets for INFANTS and YOUNG CHILDREN, whose digestive powers are more limited than those of adults. Under all these conditions, it is a question of "tempering the wind to the shorn lamb," or of favoring the alimentary tract which is not equal to much strain by giving it a relatively easy digestive task.

Persons who spend much time OUT-OF-DOORS, those who take MUCH EXERCISE, and those who are blessed with an UNUSUALLY HEALTHY DIGESTIVE TRACT can often digest without apparent difficulty larger amounts of food and foods which are harder to digest than less robust individuals can handle, but even such persons cannot continually insult the stomach with impunity.

When the stomach gives such **distress signals** as HEAVINESS, GAS, "HEART BURN," and NAUSEA, it is well to allow it a little extra rest for recovery and not to repeat the indiscretions which caused the difficulty. **Most acute digestive distress comes from the stomach** but spoiled foods and those which contain irritating substances will cause a DIARRHEA, while chronic indigestion is likely to result in the formation of GASES (through bacterial action in the intestine), which may cause acute pain through distention of the intestines. In the latter case the diet may be at fault but it is more likely that the difficulty lies in the general condition of the individual, nervous or otherwise.

The **influence of cooking on digestion** is more through making the food PALATABLE and APPETIZING than through any effect on its nutritive properties. Most raw foods are well digested, but starchy foods and those that contain tough fiber need thorough cooking in order to rupture the starch granules and to soften the fiber, so that the digestive juices can penetrate them. There is seldom more than **5 per cent difference** between the extent to which **raw or poorly cooked foods** are ultimately digested and absorbed, and the degree of utilization of the same foods when **properly cooked.** These facts are a surprise to most people and are brought out here to emphasize the completeness of the later stages of digestion even under difficult conditions, and not with any idea of condoning poor cooking. Foods, which are so poorly cooked as to be difficult to digest, frequently cause ACUTE GASTRIC DISTRESS and, if eaten habitually, may result in chronic digestive disorders.

RULES FOR PROMOTING GOOD DIGESTION

Three meals a day at REGULAR times and intervals (four to six hours apart), and of approximately equal quantity, are best for most persons.

It is usually well to make the mid-day meal somewhat lighter and the evening one somewhat heavier, when the schedule calls for active mental or physical work in the afternoon and for relaxation in the evening. With children and adults whose afternoon schedule is not taxing or who go early to bed, it is better to have the heavier meal at noon and a light supper.

Do not eat between meals.

Do not eat a full meal within two hours of going to bed.

Do not bathe or take strenuous exercise until at least an hour after meals (better two hours).

Do not eat too many foods at one meal or indulge immoderately in some favorite food.

If you know that a certain food is hard to digest, take a relatively small amount of it and make the rest of the meal on more easily digested foods.

If the digestion is out of order for any reason, or if you are under unusual conditions of strain or fatigue, take only liquid foods or small amounts of very easily digested foods until the difficulty is righted.

Cultivate a cheerful frame of mind, as well as peaceful and pleasant conditions at mealtimes.

Eat slowly. Enjoy your food and chew it well, but do not get fussy about food nor think too much of how it will affect you.

Get plenty of exercise, fresh air and sunlight.

An OCCASIONAL variation from the correct regular dietary habits will do little or no harm, provided you do not worry over having broken a rule.

QUESTIONS

1. What is digestion? Why is it necessary? Describe the alimentary tract and show how it is especially adapted for carrying out the process of digestion.

2. Describe the motor functions of the digestive tract, *i. e.*, how food is passed along through the alimentary tract from mouth to rectum. What factors influence the emptying time of the stomach? What factors influence the length of time that food material stays in the intestines? How does the length of time that material stays in the intestines affect the completeness of digestion and absorption?

3. What are the end-products of digestion of proteins, starch, cane sugar and fats? Name the principal digestive fluids that bring about the chemical break-down of these foodstuffs into their simplest components; tell where each of these digestive fluids is formed and give the main functions of each.

4. Chemical changes involved in digestion are brought about or facilitated by the presence of enzymes in the digestive fluids. What is an enzyme? What is meant by saying that enzymes are "specific" in their action? Can you name the different enzymes (and substances upon which they act) in gastric juice, pancreatic juice, and intestinal juice? What is the chemical nature of enzymes and why is their activity destroyed by boiling?

5. Describe how absorption of amino acids, simple sugars, and end-products of fat digestion takes place in the intestine. What substances taken in food can be absorbed without being chemically changed in digestion? Explain how bile helps in the digestion and absorption of fats. What substances are found in the residues at the end of the digestive tract, the feces, and what factors alter the consistency and composition of the feces?

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CHAPTER 19

METABOLISM AND THE INFLUENCE OF DUCTLESS GLANDS

METABOLISM is a word used so commonly now that many people would like to have a more definite idea of what body processes are covered by it. It is a GENERAL term used to designate all the **chemical changes which occur in living matter in the course of its vital activities.** These changes are of two kinds—CONSTRUCTIVE and DESTRUCTIVE. Constructive processes include all chemical changes by which the absorbed products of digestion are built into TISSUES. Destructive metabolism covers those processes by which either fuel foodstuffs, reserve tissue material, or even cell protoplasm if necessary, are broken down into simple substances with the liberation of energy.

Metabolism thus **begins where digestion leaves off.** Food materials are broken down in digestion, it is true, but these processes take place outside the tissues and serve merely to prepare substances for the use of the tissues. Metabolism includes only such changes as occur in LIVING matter.

The **life of the body depends upon** these building up and breaking down processes which are included under the general term of **metabolism.** The breaking down processes, which are chiefly in the nature of combustions or OXIDATIONS, are necessary to set free the ENERGY needed for muscular work, for carrying on the internal work of the body and for keeping it warm. Upon the building up processes the body is dependent for REPLACEMENTS to make good the losses of substances used for fuel, or broken down in the wear and tear of life processes, as well as for building NEW TISSUE MATERIAL in growth or pregnancy.

This discussion will be confined to the metabolism of the three chief **foodstuffs**—proteins, carbohydrates and fats. It is important to remember that each of these substances is used to some extent in the up-keep of the tissues and that all may serve as fuel, if needed. However, it can be said in a general way, that **protein** is needed **chiefly for tissue building,** and repair, while **carbohydrates and fats** supply the bulk of the body **fuel.**

Using protein as fuel is uneconomical and perhaps physiologically undesirable (see p. 153), while the other two foodstuffs are tissue-builders chiefly in the sense that an excess of them can be built into fatty tissue to serve as a reserve store of fuel.

WHAT HAPPENS TO FOODSTUFFS IN THE TISSUES

Carbohydrates. It was explained on p. 311 that the tissues could use food materials only in certain simple, standardized forms, this being the chief reason why it is necessary to reduce all the varied foods eaten to their simplest components by the process of digestion. All the starch and double sugars (cane sugar, milk sugar, malt sugar) eaten are accordingly broken down in digestion into the simple sugars of which they were made, and are delivered to the tissues almost entirely in the form of the simple sugar, GLUCOSE; *i. e.*, **the only carbohydrate found in the blood and used by the tissues is glucose.**

The products of digestion are absorbed from the intestine into the blood which passes directly to the liver by way of the portal vein. After a meal rich in carbohydrates, there will be a great deal of glucose in the blood in the PORTAL VEIN, although the **glucose content of the blood** in circulation in the REST OF THE BODY is only slightly and temporarily increased and soon returns to its remarkably **constant level.**

The **liver** is the great **regulator of the blood sugar** and the main **storage-house for excess carbohydrate** in the body. It takes the sugar brought to it from the intestine and condenses it to form a more complex and less soluble carbohydrate, just as the plant tucks its extra sugar away in the form of starch. The liver converts simple sugar into a sort of "animal starch," which is called **glycogen.** This name means sugar-former, and is given to this compound because, whenever the body needs to draw on its extra store of carbohydrate, the glycogen can be converted back into sugar again and given up to the blood. In this way the liver acts as a RESERVOIR for excess carbohydrates to keep the body from being flooded with sugar just after meals and from running short of it at other times. To a lesser extent the MUSCLES share in this function, as they also can store small amounts of glycogen.

The **amount of glycogen in the liver and muscles** naturally depends upon whether there has been a LIBERAL or SCANTY amount of CARBOHYDRATE IN THE FOOD, but there is an **upper limit** beyond which no more glycogen can be stored.

Excess carbohydrate intake, over and above the amount which can be converted into glycogen, **is stored in the form of fat** in the fatty tissues

of the body. This is why people inclined to be stout are urged to avoid taking an excess of sugar or starchy foods (as well as of fats). Something like one hundred times as many calories can be stored in the form of body fat as can be stored directly as carbohydrate (glycogen). In case of lack of food, the glycogen stores are practically exhausted in ONE OR TWO DAYS, after which the body draws largely on its reserves of fatty tissue for fuel. Thus we see that the limited amount of GLYCOGEN, which can be stored in the liver and muscles, serves more as an OVERFLOW OUTLET in carbohydrate metabolism and as a SHORT-INTERVAL FUEL RESERVE, while the MAIN DEPOTS OF EXTRA FUEL lie in the FAT DEPOSITS in various parts of the body.

The fact that the glycogen in the liver may disappear almost entirely in a short fast without producing any increase meantime in the glucose content of the blood, shows that the **tissues** must be **continually withdrawing glucose from the blood** for their own uses. The active tissues of the body, such as contracting MUSCLES and secreting GLANDS, get energy for their work from the glucose brought to them by the blood.

These and other **tissues break down glucose by combination with oxygen,** a chemical process called OXIDATION, with a resultant release of ENERGY in the form of work and heat, similar to that which takes place when fuel is oxidized or burned.[1] The oxidation of glucose does not take place all at once but proceeds through numerous intermediate stages with the formation of intermediate products and a gradual release of energy. We shall see later in this chapter that substances secreted by the ductless glands (hormones) profoundly influence carbohydrate metabolism. Also it will be recalled that several of the vitamins play an essential rôle in the oxidation of glucose, since they are found in enzymes that facilitate the intermediate steps in its oxidation. For instance, thiamine (vitamin B_1) forms part of the enzyme cocarboxylase, which brings about the splitting off of carbon dioxide from pyruvic acid. Lactic and pyruvic acids are two of the important intermediates formed and may accumulate to some extent under circumstances where carbohydrate oxidation is faulty or incomplete.

When glucose has been completely oxidized, all of the carbon is combined with oxygen to form **carbon dioxide** (a gas) and the hydrogen has also united with all the oxygen which it can hold, thus forming **water.** Glucose is made up of only the three elements, carbon, hydrogen and oxygen. Hence, when it is broken down completely by oxidation, carbon dioxide and water are the only substances produced, and a considerable amount of energy is set free.

[1] The reader is referred to Chap. 8, pp. 113-116, for a fuller discussion of how the body gets energy from fuel foods as a machine gets energy from fuel.

Carbohydrates stored as glycogen must first be broken down to the simple sugar, glucose, before being oxidized to supply energy to the body. Likewise, when it is necessary to use fat or protein for body fuel, it seems probable that they must be built over by various chemical processes into glucose, or into some of the intermediate products formed in the metabolism of glucose, before they can be used by the muscle tissues as a source of energy for muscular work. Thus we may consider the **glucose** supplied in the blood to the tissues as the **main fuel for muscular work** and should remember that by the process of oxidation, which sets free the energy for work, it is completely **broken down into** the two end products, **carbon dioxide and water.**

Fats. Fats, not being soluble in water, are carried to the tissues as finely divided particles suspended in the blood. After a meal rich in fats, the fluid part of the blood (plasma) is rendered turbid by the fat that has been absorbed from the intestines, but this extra fat leaves the blood and passes into the tissues within a few hours. Most of it **serves as body fuel** and is **oxidized by the tissues,** with a resultant release of energy similar to that which takes place in the oxidation of glucose.

Since fat is also a compound made up of carbon, hydrogen and oxygen, the **end products of its oxidation** are the same as those formed by the complete oxidation of glucose, namely **carbon dioxide and water,** though the intermediate steps are considerably more complicated and the amount of ENERGY LIBERATED IS TWO AND ONE QUARTER TIMES AS GREAT as would be produced by oxidizing an equal weight of GLUCOSE. Fat is thus a very **concentrated form of body fuel** (see p. 37). If much fat is taken along with little or no carbohydrate food, or if (as in diabetes) the final stages of its normal oxidation are interfered with, the oxidation cannot be carried to completion (carbon dioxide and water). Then some of the intermediate products, which are acid in nature, may accumulate in the tissues and blood, and appear in the urine. Such a condition is known as KETOSIS or ACIDOSIS. For this reason, as well as because it is likely to upset digestion, taking excessive amounts of fat in the food is to be avoided.

Fat taken in excess of that used to supply the body's energy needs is usually **deposited as fat in certain tissues** (adipose or fatty tissues) specialized to act as depositories for this substance. The OTHER TISSUES of the body (especially nervous tissue) contain small amounts of fats or fat-like substances called LIPOIDS, and a small part of the fat intake is used for the up-keep or repair of these tissues.

As stated previously (pp. 29 and 136), it is a considerable **advantage** to the body to have an **adequate amount of fatty tissue** to prevent undue

loss of heat from the surface (subcutaneous fat), to serve as packing about the nerves, and to support and hold in place the abdominal organs (abdominal fat), as well as to provide reserve stores of fuel which can be drawn upon in time of need. **Large amounts** of adipose tissue, on the other hand, are a great **burden** and are almost sure to shorten life by reason of the diseases that are associated with overweight (diseases of the heart and circulatory system, kidney disease, and diabetes).

The deposit of fat in the tissues always **represents fuel taken in excess of the energy needs of the body.** FAT, due to its extra high energy value, is the food material best calculated to lead to the deposit of fat in the tissues. But it should also be borne in mind that SUGARS, STARCHY FOODS and protein-rich foods can also be built over into fat by the body in ways which are not very well understood, and will undoubtedly lead to the development of fatty tissue if eaten in EXCESS of the daily fuel needs.

Proteins. The **amino acids** which are the **end products of protein digestion** are absorbed into the blood, are carried in this form to the tissues, and are rapidly taken up by the tissues from the blood. The amino acids that are **absorbed by the tissues** after a meal disappear within a few hours, and there is sufficient evidence to believe that they are **used in one of two ways:**

(1) Recombined in the right proportions to make the different tissue proteins needed for the building or repair of tissues.[2]

(2) Subjected to processes by which the nitrogen-containing part of the compound is split off, while the non-nitrogenous fragment that remains is either oxidized directly or converted into glucose, and is then available for any of the uses outlined above for that substance.

Only a relatively small amount of the protein intake is needed for tissue building or repair. It is one of the peculiarities of metabolism that the BODY IS UNABLE TO STORE protein or other NITROGEN-CONTAINING COMPOUNDS to any appreciable extent (except in growth). Hence, all of the **amino acids consumed in excess** of those needed for tissue repair must be "**deaminized,**" *i. e.*, have the nitrogen split off. The NITROGENOUS SUBSTANCES (chiefly UREA), which the body manufactures from the nitrogen thus split off from amino acids, can neither be used as fuel nor stored, and hence they are thrown off as waste products in THE URINE.

The **non-nitrogenous part** of the amino acids is usually **oxidized directly** to form **carbon dioxide** and **water** with the liberation of ENERGY, by processes very similar to those through which the oxidation of glucose

[2] Very small amounts of amino acids are probably used to build various hormones and enzymes that are known to be amino acid derivatives.

is carried out. However, some of it may be built into GLUCOSE, in which form it can be used as a source of energy for muscular work or, if there is such a surplus of food that it is not needed as fuel, it may be stored temporarily as GLYCOGEN or worked over into FAT for more permanent deposit in the tissues.

Attention is called to the fact that the **final products of the oxidation of all three foodstuffs are the same,** CARBON DIOXIDE AND WATER, with the exception of those substances formed from the nitrogen split off from the amino acids.

TABLE XXII. SUMMARY OF METABOLISM OF FOODSTUFFS

Foodstuffs.	Delivered to tissues as	Metabolism.	
		Constructive.	Destructive.
Carbohydrates . . .	Glucose	Glycogen Fat	Carbon dioxide + water + energy
Fats	Fat	Fatty tissue	Carbon dioxide + water + energy
Proteins	Amino acids	Tissue proteins Glucose	Carbon dioxide + water + energy Nitrogenous substances excreted in the urine

When the **food intake** is **just sufficient** to meet the energy needs of the body, practically all of the glucose, fat and amino acids will be oxidized as fuel, *i. e.*, subjected to the destructive processes of metabolism. The small amount of amino acids which is always needed for the up-keep of the tissue proteins, would be about the only material used for up-building processes. However, if the **food supplies energy in excess** of the body needs, whatever excess food material is provided will follow the route indicated in Table XXII, by arrows pointing to constructive processes, *i. e.*, the excess will be chiefly built into glycogen or fat for storage. Lastly, if the **energy supplied** by the food is **inadequate** to meet the body needs, the insufficiency will be made up by the destruction of some tissue materials; *i. e.*, the body will get the needed energy by oxidizing its fuel reserves, first the

stored glycogen, then fatty tissues, and finally tissue proteins in case of dire necessity. These must be broken down into glucose, fatty acids, glycerin and amino acids before oxidation. In periods of growth or recovery from a wasting illness, extra material is needed for the constructive processes, *i. e.*, for the building and repair of tissue material.

Thus, by the chemical changes outlined in this chapter, and designated under the name of metabolism, the **tissues** are able to **get energy out of the food materials** brought to them by the blood, and themselves to be **built up** or **broken down** as may suit the current needs of the body. Moreover, it is by metabolic processes that the tissues are able to recombine the very simple food materials, brought to them by the blood, in such a manner as to **build** the **substances characteristic of particular tissues** and of different species of animals. Food substances like starch, egg white, mutton fat, and olive oil, which are quite alien to the body, are reduced to their simplest building stones by digestion, and these building stones are then combined by metabolic processes to form quite different materials like glycogen, muscle protein and human fat, which are needed for the maintenance of the various tissues of the body.

Lastly it should be remembered that **metabolism is a broader term** than this discussion might indicate, and includes many chemical changes other than those connected with the utilization of the fuel foodstuffs. The metabolism of the MINERAL ELEMENTS and of the CELL NUCLEI should not be ignored in a more complete discussion of the subject, and other body processes include chemical changes which it is impossible to describe in a book of this general character.

INFLUENCE OF THE DUCTLESS GLANDS ON METABOLISM

Perhaps the most important factor in directing and coordinating the metabolism of the different tissues is the influence of a number of small organs scattered throughout the body but grouped together under the term, the **ductless** or **endocrine** glands. They get this name because, while they consist of glandular tissue, they give up the characteristic substances which they manufacture DIRECTLY TO THE BLOOD circulating through them, rather than pouring their secretions out through a duct. Hence, they are said to have INTERNAL SECRETIONS.

The organs of internal secretion are interrelated and work together to **regulate** and **coordinate** the **activities of the tissues.** When they are functioning normally, one is completely unaware of their existence and the metabolism of the body goes smoothly in all respects. When one or more of them becomes OVERACTIVE or UNDERACTIVE, the normal EQUILIBRIUM

of the "endocrine system" is disturbed, leading to more or less grave **abnormalities of growth, metabolism** or **body functioning.**

Ductless glands produce their effects by means of definite chemical compounds, which they manufacture and which are carried by the blood through the whole body. The characteristic substances secreted by the different ductless glands are known as **hormones,** and they have been called the "**chemical messengers**" of the body. When an individual wishes to do external work, he sends messages from the brain to the voluntary muscles by means of NERVES, and coordination of the different muscles is secured through the central nervous system. The nerves have been likened to the telegraph system of the body. The central nervous system, *i. e.*, the brain and spinal cord, is in charge of CONSCIOUSNESS, of receiving SENSATIONS from without, and of directing the action of the VOLUNTARY MUSCLES.

But what are known as the "**vegetative functions**" of the body are fortunately so organized as to be largely independent of influences from the central nervous system. These functions, over which thought has little or no control and whose workings do not obtrude themselves into consciousness, include the HEART BEAT and RESPIRATION, functioning of the ABDOMINAL ORGANS, maintenance of BLOOD PRESSURE, the work of the GLANDS and of the INVOLUNTARY MUSCLES (such as those of the digestive tract), as well as metabolism in the tissue cells. **Control** of these functions is through the sympathetic or **autonomic nervous system** and through the **hormones** secreted into the blood.

The **circulatory system** constitutes the means of TRANSPORTING MATERIALS from one part of the body to another. The blood is the carrier of NUTRIENT SUBSTANCES to the tissues, of WASTE PRODUCTS away from them, and of the HORMONES which regulate and coordinate their activities. Through this channel it is possible for the **hormone** secreted by a gland in one part of the body to **act on some distant part** or to **influence tissues all over the body** almost simultaneously—*e. g.*, the hormone, adrenin or adrenalin, secreted by the adrenal glands just over the kidneys, raises blood pressure and quickens the heart beat and respiration; the hormone thyroxin, formed by the thyroid gland in the neck, increases the rate of oxidation in the tissues throughout the whole body.

When the **active principle** or hormone can be **extracted** from a gland and **purified** for use in medicine, the same effect is obtained as by giving the gland tissue, only the purified hormone acts more efficiently and in smaller doses. About twenty hormones are now known, more than half of which have been isolated in purified form and studied as to their chemical

structure. Most of them prove to be either related to proteins (amino acid derivatives) or derived from an important fatlike substance in blood and tissues, cholesterol. Several of them can even be synthesized in the laboratory.

In general, we may say that the **ductless glands influence the body along the following lines**:

(1) Growth.
(2) Sexual development.
(3) Vegetative functions.
(4) Metabolism and general nutrition.

GROWTH and SEXUAL DEVELOPMENT are chiefly influenced by internal secretions from the thymus, pituitary, pineal, adrenal and sex glands.

The hormones of the thyroid, adrenal and pituitary glands exert a profound effect upon such VEGETATIVE FUNCTIONS as the blood pressure, heart beat and respiration, and contractions of the smooth muscle in the alimentary and genital tracts. The influence of certain glands, especially the thyroid and pituitary, upon mentality is also very marked.

Comprehensive discussion of the ductless glands, their numerous hormones and the many effects of these secretions on the body, is beyond the scope of this book. The discussion that follows is limited to the specific ways in which certain glands influence METABOLISM AND GENERAL NUTRITION.

Thyroid Gland. The thyroid gland is situated in the lower part of the neck, with lobes on either side and a connecting isthmus across the trachea. It secretes an IODINE-CONTAINING SUBSTANCE called **thyroxin**, which has a powerful effect in increasing the **rate of oxidation processes** in the tissues (basal metabolism). It also in some way can influence the DEPOSITION OF FAT in the tissues.

When the thyroid is UNDERACTIVE and secretes too little thyroxin this is evidenced by LOW BASAL METABOLISM, sluggish body processes, and overgrowth of fatty tissues. If this condition occurs from birth or in early life, it is known as CRETINISM, if in adult life, it is called MYXEDEMA. Underactivity of the thyroid is also designated by the term HYPOTHYROIDISM, and overactivity of this gland is called HYPERTHYROIDISM.

When the thyroid is OVERACTIVE and secretes too much thyroxin, **exophthalmic** or **toxic goiter** results, a condition where BASAL METABOLISM is abnormally HIGH, heart rate rapid, body emaciated, and eyes fre-

quently protruding (Fig. 67, p. 344). All the body processes are speeded up and there is excessive nervousness. The thyroid may or may not be enlarged.[3] A person with overactive thyroid becomes thin because it is often impossible for him to eat enough food to supply his unusually high energy requirement.

In order to assist in DIAGNOSING ABNORMALITIES OF THE THYROID GLAND (and also in some other diseased conditions), physicians and hospitals now very commonly use devices for determining the BASAL METABOLIC RATE (see p. 131). Such "**metabolism tests**" consist of having the patient re-



Fig. 65. Effect of thyroid extract (begun at 10½ years of age) on growth of a child whose thyroid was under-active. Note improvement of general appearance and mentality, which parallel the rapid growth and better proportions of the body. (The Practitioner.)

breathe the air in a closed circuit, while lying absolutely quiet and relaxed, before breakfast (see Fig. 68). The latter precautions are necessary to rule out the effects of food and muscular tension in increasing the amount of oxygen consumed (pp. 132 and 139). By measuring the amount of OXYGEN CONSUMED under these circumstances, it is possible to calculate the ENERGY PRODUCED (calories) by the oxidative processes in the tissues, and

[3] In **simple goiter,** which is endemic in certain regions where the IODINE SUPPLY IS LOW (see p. 197), there is enlargement of the thyroid because it tries to make up by extra glandular tissue for the deficient supply of material for making its secretion, but the symptoms of rapid metabolism are lacking because there is no overproduction of thyroxin.

to compare it with the theoretical amount of energy which should be produced in the basal metabolism of a normal person of the same age, sex,



A *B*

Fig. 66. *A*, Child with myxedema (underactive thyroid). Note saddle-nose, puffy look of face, and appearance of low mentality.

B, Same girl after treatment with thyroid extract. Note luxuriant growth of hair, change in features and expression. (Lisser in Blumer's "Bedside Diagnosis.")



A *B* *C*

Fig. 67. Patient before and after removal of thyroid gland because of exophthalmic goiter (overactive thyroid). *A*, Before operation. Note thinness, tense expression, protruding eyes and enlarged thyroid. *B*, Two weeks after operation. *C*, A year after operation. (Crile, "The Thyroid Gland.")

size, etc. When the report says +10, it means that the basal metabolism was 10 per cent higher than that expected for the theoretical normal; −20 means a basal metabolism 20 per cent lower than the normal to be ex-

pected for that individual. Variations of 5–10 per cent above or below the theoretical normal, or changes from time to time which amount to only a few per cent, mean little or nothing, but large and consistent variations from the normal are very significant.

How potent a regulator of energy metabolism the thyroid gland is may be seen from the fact that the basal metabolism may be increased 75 per cent in severe cases of overproduction of thyroxin (exophthalmic goiter), and will be 30–50 per cent above normal in less severe cases. Underproduc-



Fig. 68. Latest type of portable respiration apparatus for measuring basal metabolism. The oxygen supply, drum for recording amount of oxygen consumed and other parts are concealed within the case. The subject is in position with mouthpiece inserted and noseclip attached. (Courtesy of the Sanborn Company.)

tion of thyroxin may depress the basal metabolism 15–30 per cent. When the minute amounts of this substance in the blood exert such powerful effects, it is really remarkable that in health the secretion of thyroxin is regulated with such nicety as to cause the basal metabolism of an individual to be practically constant.

Adrenal Glands. These two small glands are located just above the kidneys (see Fig. 72, p. 355) and secrete hormones into the blood which, among their other effects, have a quick but transient effect upon energy

metabolism. The hormone secreted by the inner portion of these glands is known as ADRENIN or ADRENALIN.[1] Ordinarily this potent hormone is released in very small amounts but under the influence of fear, anger or other emotional states extra quantities of adrenin are poured into the blood and gear the whole body for the muscular action that would accompany such emotions under primitive conditions (flight in case of fear). Heartbeat is

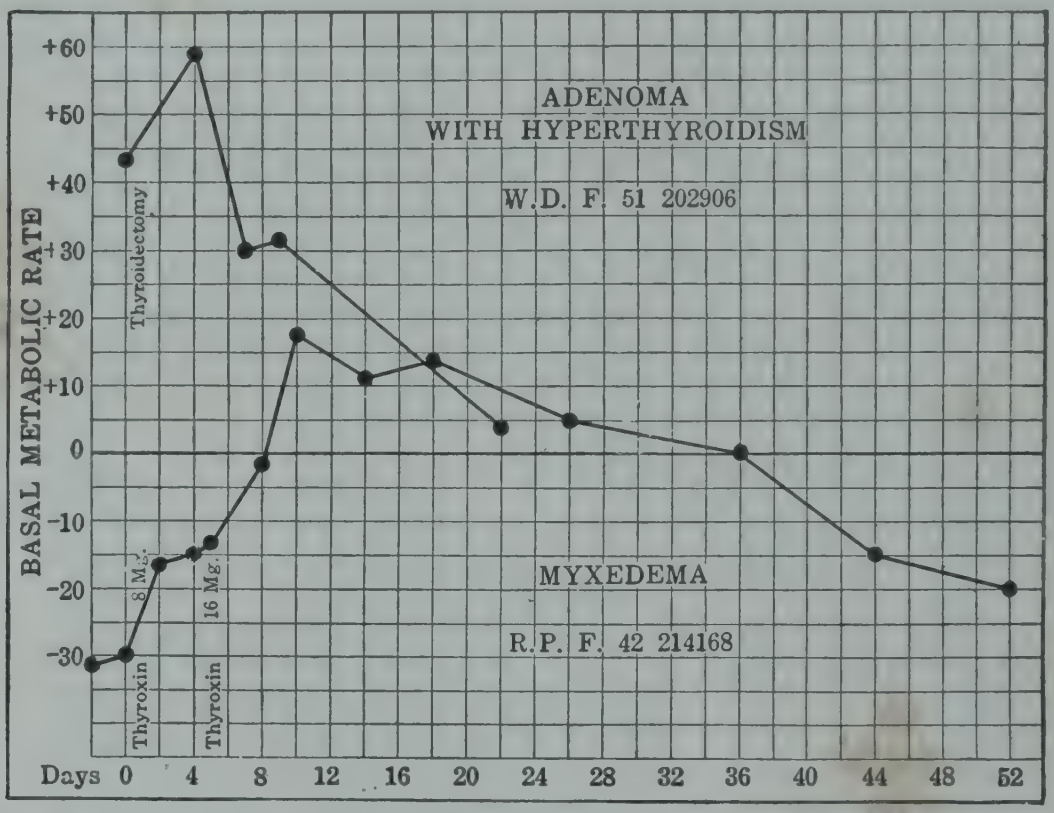


Fig. 69. Curves showing the basal metabolic rates when the thyroid gland is overactive (upper curve) and when it is underactive (lower curve). Note that the high basal metabolism (+40) in hyperthyroidism returns to the normal rate (±0) after removal of the thyroid gland (thyroidectomy), while the low rate (—30) in myxedema is raised by the administration of thyroxin, the active principle of the thyroid gland. (Boothby.)

quickened, blood pressure rises, extra sugar is released from the liver into the blood, and blood is shifted from the internal organs to the muscles. Among these and other effects of adrenin is its action in increasing the rate of oxidation in the tissues (basal metabolism). Its influence in this respect is much less, quicker to take effect and of shorter duration, than that of thyroxin.

[1] Another name for this hormone is epinephrin, and the glands are sometimes called the suprarenal glands.

The outer portion (cortex) of these glands acts like a separate gland and secretes a special hormone called CORTIN, which is essential for life.[5] Cortin has a specific action upon the metabolism of the mineral elements, SODIUM and POTASSIUM. When it is lacking, there is increased excretion of sodium in the urine and subnormal sodium content of the blood; the concentration of potassium in the blood is abnormally high. Hence the adrenal cortex through its internal secretion plays an important rôle in regulating the mineral metabolism of the body.

Parathyroids. These glands also secrete a hormone that has a decided influence on mineral metabolism. They are minute structures, embedded in or closely associated with the thyroid gland, usually one pair to each lobe of the gland. When the parathyroids are completely removed, the amount of the element calcium circulating in the blood is so much reduced that TETANY (convulsive muscular tremors) sets in, and death results. When they are underactive, blood calcium is below normal; in rare cases where they are overactive blood calcium is at a high level and calcium drained away in the urine to an extent that the bones suffer excessive loss of calcium. The chief function of these glands thus seems to be to help preserve the proper EQUILIBRIUM BETWEEN THE CALCIUM IN BONES AND THAT IN THE BLOOD. In regulating the calcium content of the blood, parathyroid hormone is intimately concerned in the metabolism of calcium.

Pancreas. In this gland we also have small groups of special cells (called islands of Langerhans) scattered throughout the ordinary gland tissue, which manufacture a very important hormone. The pancreas thus has both an EXTERNAL secretion (pancreatic juice, see p. 315) which it pours into the digestive tract through a duct, and an INTERNAL secretion which it gives up to the blood.

The hormone secreted by the pancreas is called **insulin.** It is necessary to enable the tissues to utilize the glucose (and to some extent the other foodstuffs) brought to them by the blood, and seems to act like the spark which sets off some combustible mixture. It also promotes storage of glucose as glycogen in the liver and muscle. When the tissues lose the ability to store or oxidize carbohydrates (pp. 335-6), glucose accumulates in the blood and is excreted in the urine. This abnormal metabolic condition is known as **diabetes.** It is due chiefly to an INSUFFICIENT SUPPLY of the pancreatic hormone INSULIN, though the adrenal and pituitary glands are also

[5] When secretion of this hormone fails in Addison's disease, there is bronzing of the skin, extreme muscular weakness and emaciation, and death usually results unless the patient can be kept alive by injections of cortin. A diet high in sodium and low in potassium also helps prolong life.

concerned in carbohydrate metabolism. Injection of suitable amounts of insulin causes the abnormally high blood sugar in diabetics to fall rapidly and return to normal (Fig. 71).

In mild diabetes the disease can often be held in check merely by **limiting the quantity of carbohydrate food eaten.** With only small amounts of sugars and starches to be broken down into glucose in the digestive tract, the amount of this substance carried to the tissues will not exceed what they can store or oxidize with the limited amount of insulin available. In the more severe cases, however, it is necessary to give **insulin by sub-**



Fig. 70. Prismatic crystals of insulin. These crystals are all beautifully transparent, the appearance here that suggests opaqueness is due simply to difficulties of focus. (Courtesy of Dr. J. J. Abel.)

cutaneous injections. When this is done, the body can handle somewhat larger amounts of carbohydrate and a much better nutritive condition can be maintained, although the diet still has to be carefully controlled.

Pituitary Gland. This gland, which lies in a groove at the base of the brain, also secretes very powerful substances into the blood. It is composed of two distinct parts, called the anterior and posterior lobes, each of which secretes a number of different hormones.

The anterior lobe of the pituitary is often referred to as the "master gland" among the ductless or endocrine glands of the body. This is be-

cause it secretes hormones that have a MARKED INFLUENCE UPON THE OTHER DUCTLESS GLANDS. It secretes at least seven different hormones but we will concern ourselves here only with those that affect metabolism through their influence on other glands. The physiological effects of anterior pituitary hormones include:

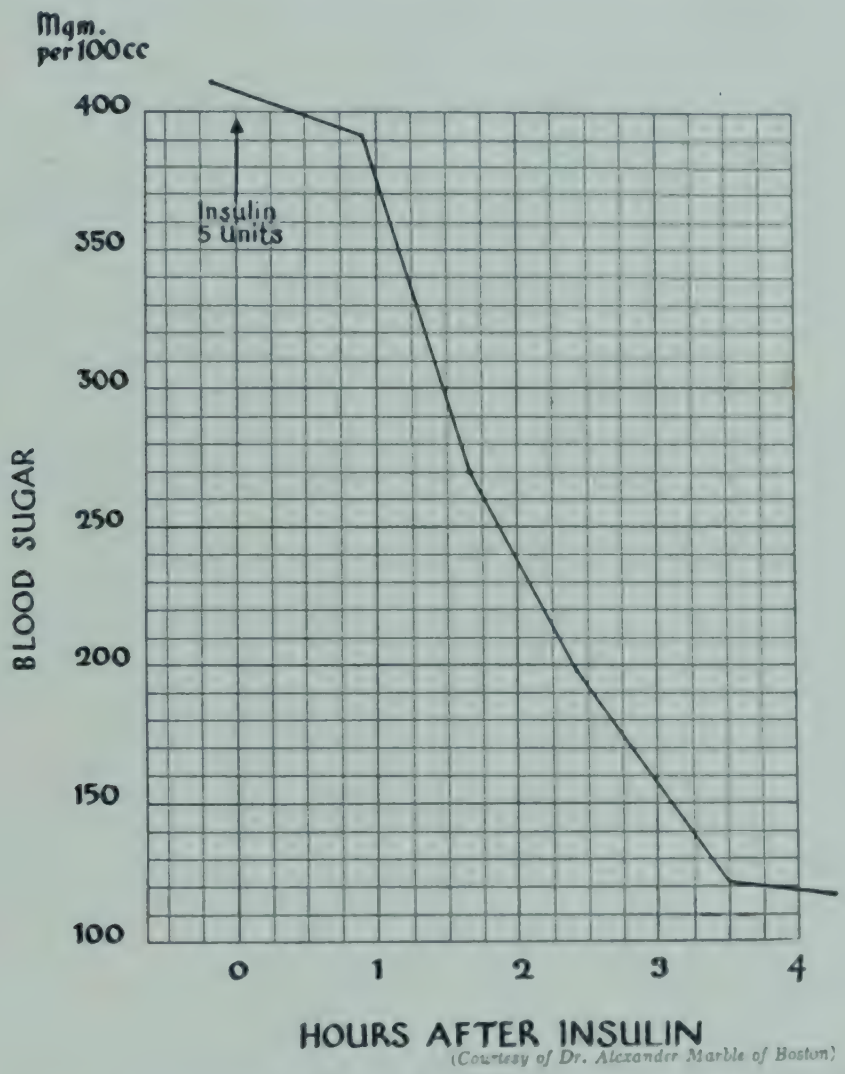


Fig. 71. Effect of injecting five units of insulin into a patient with severe diabetes and sugar content of the blood about four times the normal amount. Note rapid response with fall of blood sugar almost to normal.

Stimulation of the thyroid, parathyroid, adrenal (cortex) and sex glands.

Action on carbohydrate metabolism which is the opposite of that of the pancreatic hormone, insulin.

Thus the anterior pituitary has a direct influence on carbohydrate metab-

olism through a hormone that is said to be "diabetogenic" in that it tends to flood the body with sugar by releasing it from liver glycogen, while insulin promotes the utilization of carbohydrates. It also has an indirect influence on basal energy production, and on the metabolism of carbohydrate, fats, and mineral elements, through the effects of its hormones in stimulating other ductless glands.

QUESTIONS

1. Define metabolism. Why is digestion not included in metabolism? What is meant by metabolism of the fuel foodstuffs? by mineral metabolism? What happens when the intake of fuel foodstuffs is just about sufficient for the energy needs of the body, when it is in excess of body needs, and when it is inadequate for body needs?

2. Describe the metabolism of carbohydrate, covering the following points: the form in which it is absorbed from the intestine into the blood, the form in which it is carried in the blood to the tissues, the rôle of the liver in carbohydrate metabolism, the fate of glucose in the tissues (both that needed to supply energy and that in excess of immediate needs), the final products of carbohydrate metabolism.

3. Describe the metabolism of fats, covering the same general points listed above for carbohydrate metabolism. Describe the chemical changes that amino acids undergo in the tissues, including the fate of both the nitrogenous and non-nitrogenous parts of the molecule. What are the chief end products of the metabolism of the three fuel foodstuffs?

4. What are the endocrine or ductless glands, and what is a hormone? What is the hormone secreted by the thyroid gland and what unique constituent does it contain? How does the thyroid hormone influence metabolism, and what are the effects of oversecretion and undersecretion of this hormone?

5. What gland secretes insulin and what is its rôle in carbohydrate metabolism? In what disease is insulin supplied in insufficient amounts? What symptoms are indicative of insulin lack and in what two ways may the disease be treated?

6. For each of the following ductless glands, tell what influence their hormone or hormones have on metabolism: adrenal cortex, parathyroids, anterior lobe of the pituitary gland.

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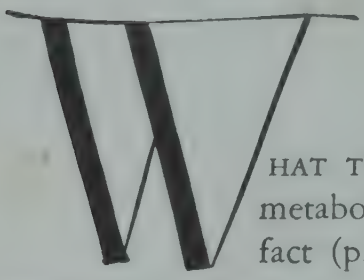
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CHAPTER 20

EXCRETION AND THE FACTORS AFFECTING IT



WHAT THE WASTE PRODUCTS ARE. In discussing the metabolism of the fuel foodstuffs, we emphasized the fact (p. 339) that all three of them yield the same end products of oxidation, namely **carbon dioxide** and **water.** These products are formed by the burning of any fuel, such as wood, coal, or gasoline. Although the body has use for a certain amount of carbon dioxide and water, the excess of them which is constantly being formed must be excreted.

In addition to the gases formed when fuel burns, there are ashes left behind. Certain **nitrogen-containing substances** and several kinds of **inorganic salts,** chiefly end products of the metabolism of proteins, may be thought of as the ashes of metabolism, since they are of no use to the body, are difficult to get rid of, and may cause trouble if they are not excreted. These troublesome end products we may think of as the clinkers, which are likely to clog up the grate and slow down the fire. We may divide the waste products, which it is necessary to keep from accumulating in the body, into the following groups:

(1) Carbon dioxide.
(2) Water.
(3) Nitrogenous substances.
(4) Mineral salts.

Organs of Excretion. These are likewise four in number—the lungs, the skin, the kidneys, and the intestine. The table below gives a brief summary of which waste products are handled by the different organs of excretion, while the functioning of each of these organs will be described somewhat more in detail in the paragraphs which follow.

Lungs	excrete **carbon dioxide** and **water.**
Skin	excretes mainly **water.**
Kidneys	excrete **water, salts** and **nitrogenous substances.**
Intestine	excretes **mineral salts, waste products in bile,** the food residues and some water.

Excretion through the Lungs. The lungs are the only channel for GETTING RID OF THE SURPLUS CARBON DIOXIDE that is continually being

formed by the oxidation of fuel-foods in the tissues. Their function is doubly important, since they are also solely responsible for RECHARGING THE BLOOD WITH OXYGEN, which is essential for oxidative processes in the tissues without which life cannot be maintained.

Excess **carbon dioxide** passes into the blood from the tissues, and is held in loose chemical and physical combinations in the circulating blood. When the blood reaches the lungs, it is brought into contact in the fine capillaries with air in the innumerable small air sacs of the lungs—that is, there is between the blood and air only a double membrane consisting of the very thin walls of the capillary and of the air sac, and this partition is of a nature to permit the free exchange of gases. Accordingly, **in passing through the lungs the blood loses about $\frac{1}{6}$ of its carbon dioxide content** in gaseous form to the carbon dioxide-poor air in the lungs, and takes up from the inspired air gaseous OXYGEN, which is carried to the tissues in loose chemical combination with the blood pigment, HEMOGLOBIN. Fresh air contains only 0.03 to 0.04 per cent of carbon dioxide[1] and about 20 per cent of oxygen. The process of RESPIRATION in animals consists essentially of taking up 4–5 per cent of oxygen from the inspired air and giving off 3–4 per cent of carbon dioxide to the expired air. Incidentally the inspired air becomes saturated with **water vapor** while in the lungs, which accounts for the considerable and constant loss of water through the lungs.

Under **factors which influence respiration** may be listed anything which affects the depth or frequency of the breathing. The chest muscles and diaphragm form a bellows by means of which air is alternately sucked into and forced out of the lungs, these organs themselves being merely passive. **Frequency** of respiration is controlled by the RESPIRATORY CENTER in the brain, this center in turn being chiefly affected by the CARBON DIOXIDE CONTENT OF THE BLOOD.[2] Thus after exercise, during which the production of carbon dioxide is more rapid, stimulation of the respiratory center causes an increased rate of breathing, with the result that the excess of carbon dioxide is removed from the body through the increased

[1] Although the carbon dioxide content of the air is increased in cities and in crowded rooms, it seldom reaches a point where it contaminates the air to any serious extent. It is kept from accumulating in the atmosphere as a whole, because plants take up from the air the carbon dioxide which animals give off. The very real discomfort felt in a poorly ventilated room is mainly due to heat, excessive moisture content and stagnation of the air, rather than to excessive carbon dioxide.

[2] This is one of the reasons why it would be disadvantageous for the blood to lose too much of its carbon dioxide content in passing through the lungs. Such a condition, which may be induced by over-ventilating the lungs through forced breathing, results in a temporary suspension of breathing until the carbon dioxide content of the blood has been renewed to the level where it stimulates the respiratory center.

ventilation of the lungs. **Depth** of respiration is a good deal a matter of habit and posture. In ordinary shallow breathing only about $\frac{1}{6}$ to $\frac{1}{5}$ of the air contained in the lungs is involved. This means that, although the whole volume of air is probably fairly efficiently renewed at least twice every minute,[3] the upper portion of the lungs usually gets little exercise. The need of taking deep breaths occasionally will be apparent. Efficient respiration is an important factor in good health; normal conditions which affect respiration are **habit, posture** and **exercise.**

Excretion through the Skin. Through the activity of the sweat glands in the skin, **water** is lost from the body in the perspiration. Although the perspiration also contains small amounts of the nitrogenous waste product, urea, and of mineral salts (also traces of water-soluble vitamins), the value of the skin as an excretory organ is chiefly confined to its influence in removing water. The average person loses about a quart of water daily through the combined channels of the skin (perspiration) and lungs (respiration), five or six ounces more in the stool, and the remainder through the kidneys. The relative amount excreted by the skin will be largely determined by the amount of perspiration NEEDED to take care of ridding the body of excess heat, *i. e.*, for the TEMPERATURE REGULATION of the body. In HOT WEATHER or after extra heat production through EXERCISE, there is greatly increased perspiration and evaporation of water from the body surface in effecting the loss of heat necessary to temperature regulation. On a cold or humid day, or when there is little physical exertion, much less water is excreted through the skin and more by the kidneys. Hence the **temperature** and **humidity** of the surrounding air, along with **exercise,** are the chief factors that affect the excretion of water by means of the skin.

Excretion by the Kidneys. The kidneys are two glandular organs situated in the back of the abdominal cavity on either side of the spinal column at about the level of the twelfth rib. They are directly connected, by means of a large artery and vein respectively, with the main arterial and venous trunks of the body (see Fig. 72), so that they are **perfused by an exceptionally large amount of blood.** They secrete the **urine,** a fluid which is secreted continuously (although more rapidly under certain stimuli). It is collected in the urinary bladder, and is discharged at intervals through a duct leading to the exterior.

Of the waste products excreted in the urine, **water** is by far the largest in quantity (urine consists of about 96 per cent water). Also a greater proportion of the water loss from the body is effected by the kidneys than by any other route, though it is notable that some water leaves the body

[3] The usual rate of breathing is fourteen to eighteen times per minute.

through each of the excretory channels. When an unusual loss of water through the skin takes place in hot weather (or through the alimentary tract in such abnormal conditions as vomiting and diarrhea), the amount excreted by the kidneys is correspondingly less.

The next most important constituents of urine are the **nitrogenous end products of protein metabolism** (see p. 338). One of these alone, **urea,** makes up about half of the total solids of the urine and constitutes the form in which 80–90 per cent of the nitrogen from metabolized proteins is

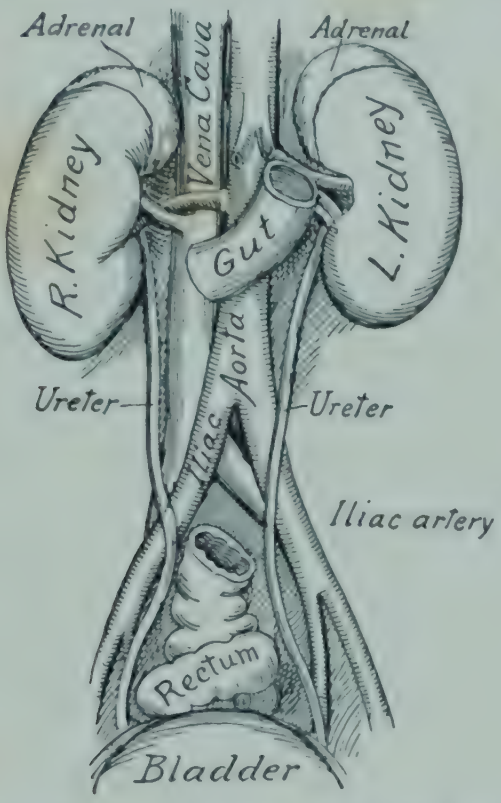


Fig. 72. Diagram showing anatomy of the urinary tract. Note location of kidneys (with adrenal glands above), their direct connection with main arteries and veins, also their outlet through the ureters and bladder. (From Hoxie, "Medicine for Nurses.")

excreted. Smaller amounts of URIC ACID, CREATININE and AMMONIUM SALTS are the other nitrogen-containing constituents of urine. These nitrogenous waste products can be eliminated from the body ONLY through the activity of the kidneys. While they are not toxic in the amounts ordinarily present in the blood, if the kidneys fail to excrete these substances efficiently and they accumulate in the blood to a certain level, toxic symptoms set in. This is the cause of the uremic poisoning which occurs in the later stages of kidney disease (Bright's disease or nephritis).

Finally, several kinds of **mineral salts** are excreted by the kidneys, which share with the intestine the duty of ridding the body of an excess of these substances, although the **bulk of the salts leaves the body in the urine.** SODIUM CHLORIDE, common salt, is excreted solely in the urine and its source is the salt eaten in the food. PHOSPHATES and SULFATES come chiefly from the metabolism of the proteins which contain phosphorus and sulfur. Other salts are largely those ingested in the food. When the kidneys fail to function well, salts may accumulate in the blood and tissues, holding back sufficient water to dilute them to their normal concentration in the tissues (see p. 168) and thus causing the bloating or edema which often accompanies diseases of the kidneys.

Factors Influencing Kidney Excretion.— { amount of blood supply; action of diuretics; amount of water taken; health of the kidneys }

The extent to which the **amount of blood** sent through the kidney influences the secretion of urine is often unappreciated, though the importance of this factor is obvious when pointed out. Naturally a larger volume of urine is secreted when a great deal of blood is shunted through the renal[4] circulation than when the kidneys are less richly supplied with blood. This accounts for the INCREASED FLOW OF URINE under conditions of NERVOUS STIMULATION, and for a slightly decreased secretion when large amounts of blood are diverted to other parts of the body. **Diuretics** are substances which exert a stimulating effect on the kidneys. COFFEE and TEA both stimulate the kidneys to increased secretion of urine and are the only diuretics in common use except WATER, which is an excellent diuretic.

It is very generally recognized that **drinking large amounts of water** results in the secretion of a much increased volume of urine. This urine is very light in color and more dilute than usual in its content of dissolved solids. In other words, the amount of pigment and waste products excreted remains about the same, so that the extra water merely renders the urine more dilute. The common conception that drinking a great deal of water "flushes the system" of many waste products which would otherwise not be excreted is a rather exaggerated notion, since ordinarily the kidneys and other organs of excretion rid the body of waste material efficiently day by day and do not allow "toxic substances" to accumulate even when the water intake is less than the optimum. However, there are

[4] Renal is an adjective which means belonging to the kidney. Hence the term adrenal glands signifies glands above the kidney.

many reasons why a liberal consumption of water is a good hygienic measure, as water is needed in the body for many purposes (see pp. 171–172). In addition, conditions are probably more favorable for the kidney to do its work when plenty of water is excreted along with the waste products than when it has to secrete a very concentrated urine. Thus, drinking plenty of water (6–8 glasses per day) is to be encouraged, but taking an excessive amount of it confers no special benefit and merely places an added burden on the kidneys.

Which brings us to the fourth, and probably the most important, factor in urinary excretion, namely the maintenance of **healthy kidney tissues.** We know that there is a large "factor of safety" in this respect. The body is equipped with two of those organs, while it has been estimated that half of one kidney will suffice to meet the body needs for excretion through the urine, provided it is in healthy condition. It seems reasonable to believe (although not absolutely established by scientific experiments), that the kidneys, like any other organs, are benefited by conditions which make for an easier performance of their duties, and are apt to give out in time if subjected to undue STRAIN or constant IRRITATION. Alcohol and pepper are both kidney irritants. It has been maintained that the necessity of excreting large amounts of nitrogenous waste products and of mineral salts, such as follows the habitual eating of excessive quantities of protein-rich foods and salt, constitutes an undue strain on the kidneys which may lead to their breakdown in later life. It is certainly true that conditions such as high blood pressure and heart disease will eventually result in circulatory damage to the kidneys and such diseases are, therefore, almost invariably associated in their later stages with a failure of the kidneys to function properly. Other causes of damage to the kidneys are BACTERIAL INVASION of the kidneys themselves, bacterial TOXINS produced by a general or local infection (scarlet fever, diphtheria, tonsillitis, etc.), and POISONING with certain substances such as compounds of the heavy metals (*e. g.*, bichloride of mercury).

Whatever the cause, **damage to the kidney tissues results in** a less efficient functioning of these organs which may show itself in one of several ways according to the severity of the kidney injury—namely, INABILITY TO PRODUCE A MORE DILUTE OR MORE CONCENTRATED URINE, when fluids are forced or withdrawn; a DIMINISHED EXCRETION of SALTS and NITROGENOUS SUBSTANCES, often accompanied by increased secretion of water: a DIMINISHED EXCRETION both of WATER and of the waste products in the urine; the appearance in the urine of PROTEIN, an abnormal constituent whose presence is usually indicative of nephritis.

When the kidneys are known to be WEAKENED OR DISEASED, the natural procedure is to lighten their load by **limiting the intake of those substances** which give rise in metabolism to end products that have to be **excreted by the kidneys.** Hence, the amount of PROTEIN and SALT in the diet of nephritic persons is usually kept down to the minimum needed for body maintenance, and in addition it is sometimes necessary to limit the WATER intake in nephritis.

Excretion through the Intestine. The material expelled through the anus, the opening at the lower end of the alimentary canal, is called feces, and the feces consist of

(1) Small amounts of true EXCRETORY MATERIAL.
(2) INDIGESTIBLE and UNDIGESTED FOOD RESIDUES.
(3) Residues from DIGESTIVE SECRETIONS, MUCUS, and CELL DEBRIS from the lining of the alimentary tract.
(4) BACTERIA and the products of their action.
(5) WATER.

It will be apparent that the **bulk of the feces** is made up of **food and digestive residues,** and that their expulsion is necessary more for the purpose of clearing the digestive tract to take care of new food material than for getting rid of the waste products of metabolism. Nevertheless, some MINERAL SALTS (notably salts of calcium and phosphorus) are excreted through the intestinal wall into the lower digestive tract and certain WASTE PRODUCTS ARE FOUND IN THE BILE, which is secreted by the liver and emptied into the duodenum. These substances together constitute the true excretory material contained in the feces. The PIGMENT which gives the feces their brown color may also be included in this class, since it is formed from the bile pigment, which in turn comes from the blood pigment.

Feces of ordinary semisolid consistency contain 60–70 per cent of **water,** but the water content will be higher if the fecal material is hurried through the alimentary tract, and lower when its excretion is long delayed. About one-tenth or more of the feces consists of **bacteria** (both living and dead), and the number excreted per day has been estimated as varying between 50 and 500 billions. The presence of bacteria in the intestinal contents is entirely normal and some of them may even be beneficial in that they synthesize B-complex vitamins (if these vitamins are released for absorption, which is as yet undetermined). However, too large a number of bacteria or the predominance of the more harmful types is to be deplored from the standpoint of intestinal hygiene. The predominance of the fermentative types of bacteria (those that act on carbohydrates) over the pu-

trefactive types (that break down protein material) is recommended as advantageous. The number and strains of bacteria which flourish in the intestine is chiefly determined by the CHARACTER OF THE DIET and the CONDITION OF THE INDIVIDUAL.

Factors Which Affect Excretion through the Intestines. These are summarized below:

FECAL EXCRETION INFLUENCED BY	**Tone of intestinal muscles**—affected by		General condition
			Diet
			Posture
			Exercise
	Sensitiveness to nervous stimuli leading to defecation—affected by		Individual nervous sensitiveness
			Habit
			Psychic influences
	Nature of intestinal contents—affected by	Bulk and consistency	Depends on amounts of cellulose, water, and gas
		Lubrication	Depends on amount of water and undigested fat
			Organic acids, especially in fruits and sour milk
		Presence of substances which stimulate peristalsis	Irritating substances such as hard materials, undigested food or spoiled food
			Laxatives, enemas, etc.

It seems worth while to take up this subject in considerable detail, since **constipation,** or inefficient excretion through the intestine, is one of the most prevalent difficulties of modern people. This is due largely to faulty habits of living and to eating highly refined foods from which most of the roughage has been removed, but it should be noted from the many factors listed in the above table that the problem of constipation is far from a simple one. It is often necessary to right several faulty conditions in order to secure satisfactory elimination.

One important factor is the **tone of the intestinal muscles.** If the intestinal mucosa is very sensitive or the person is in a hypersensitive nervous state, the colon may be stimulated to TOO GREAT MUSCULAR ACTIVITY, may contract excessively and shut down the cavity so as to prevent free passage of fecal material. On the other hand, when an individual is poorly nourished or in a "run-down" condition from any cause, the INTESTINAL MUSCLES are likely to be FLABBY and in POOR TONE, so that peristaltic contractions of the colon take place infrequently and with insufficient force. Such a condition of poor muscle tone of the intestine is often the primary factor responsible for constipation.

Sensitiveness to the nervous stimuli which initiate the process of defecation[5] is important. DIFFERENCES IN NERVOUS SENSITIVENESS are probably responsible for the wide differences in individuals as to the frequency with which they must empty the bowel in order to secure comfort. By IGNORING the nervous stimuli, to which the presence of feces in the rectum gives rise, the desire and ability to defecate pass, and repeating this offense results in blunting the sensitiveness to these stimuli. This explains the important part which HABIT plays in securing normal bowel movements. The normal stimulus to defecate comes after meals, especially after breakfast, and if taken advantage of at such times rather than neglected, the colon can be trained to evacuate itself at regular intervals. PSYCHIC INFLUENCES, such as hurry, fear of inability to defecate and overanxiety to have a movement daily, have the effect of inhibiting these stimuli and preventing the normal reflex which causes the colon to contract and expel its contents. In training children to proper habits of evacuation, mothers often find that over attention to and nagging about this function produce the opposite effect from the one desired. Neurotic persons often show a high degree of constipation due to psychic influences.

Under the head of the **nature of the intestinal contents,** we have grouped a number of those factors which are most apt to receive attention in correcting constipation. When the intestinal contents are of the proper **bulk** and **consistency,** they are not only easier to move along but more likely to stimulate the intestine to active muscular movements. The contents of the colon should be semisolid, nonirritating, relatively free of undigested food residues, and of sufficient bulk, in order to secure good peristaltic movements and easy propulsion of the fecal mass. The diet is largely responsible for securing these conditions. Enough HIGH-RESIDUE FOODS, that is those that contain considerable cellulose, must be taken to give bulk to the fecal material.

The presence of plenty of **water** and slight **fermentation,** which tends to break up the fecal mass by the formation of gas bubbles, both favor a SOFT, BULKY intestinal content. Hard, dry feces are difficult to push along and fail to stimulate peristalsis, especially when small in bulk. LUBRICATION between the fecal material and the intestinal wall is promoted by the presence of extra liquid or of undigested FAT. WATER is the best lubricant, since food fats are almost completely digested and absorbed before the colon is reached under ordinary circumstances.

The presence of **harsh, irritating substances,** of undigested food resi-

[5] Defecation is the act of expelling the feces through the anus, thereby emptying the rectum and lower part of the colon of their contents.

dues, of toxic or chemically irritating substances in the intestine **sets up increased peristalsis,** which tends to rid the alimentary tract of the irritating material. This may be taken advantage of when there is need to stimulate a muscularly inactive colon (*e. g.*, adding BRAN to the food), but if overdone will lead to unfortunate results such as DIARRHEA, inflamed conditions like COLITIS, and the spasmodic contractions of the intestine seen in SPASTIC CONSTIPATION. The continual taking of **cathartics** also acts as an irritant to the intestine and produces bad results in the same way. SALINE cathartics act by drawing water into the intestine, for the presence of liquid in the colon serves to stimulate peristaltic contractions. This fact is taken advantage of in the giving of ENEMAS to flush out the colon and carry off whatever fecal residues may be present, but this is an emergency measure and should not become a regular practice. The taking of enemas does not remedy any of the causes of constipation.

If the DIET is of the type which will provide a relatively soft and bulky intestinal content, if the NERVOUS FACTORS are so regulated as to be favorable, and if the INTESTINAL MUSCLES are kept in proper tone, satisfactory excretion through the intestine should take place regularly with as little attention as is devoted to the other body processes.

DIETS FOR PREVENTING CONSTIPATION

Although diet is by no means the only factor to be taken account of in constipation, it is nevertheless impossible to secure satisfactory intestinal hygiene unless a suitable diet is taken. The diet must include enough indigestible fiber, so that there will be a residue in the intestine of sufficient BULK and SOFT, SEMISOLID CONSISTENCY to be readily moved along and evacuated. A diet that consists almost entirely of low-residue foods will result in a small amount of hard, dry fecal material, which is difficult to propel, irritates the intestine without stimulating to defecation, and thus tends to remain too long in the colon. It has also been shown that diets of low mineral content (especially those poor in calcium) lead to stagnation in the colon (intestinal stasis).[6] The need for B vitamins in the diet in order to maintain proper muscular tone of the intestines has been emphasized in the section on vitamins (p. 234).

Types of Constipation. There are two kinds of constipation which are caused by diametrically opposite conditions and hence require exactly OPPOSITE TYPES OF TREATMENT. In **atonic** constipation, the infrequency of

[6] Robertson, E. C., and Doyle, M. E., "Intestinal Stasis on Low Mineral Diets," J. Nutrition, v. 9, p. 553, 1935; Robertson, E. C., "Calcium Deficiency and Intestinal Stasis," J. Nutrition, v. 15, p. 67, 1938.

bowel movements is primarily due to POOR MUSCLE TONE and SLUGGISH MUSCULAR CONTRACTIONS of the colon. In **spastic** constipation, the circular muscle fibers in some lower section of the intestine go into a SPASM OF CONTRACTION, either because of irritation from within or of a general nervous condition, so that the passage of fecal material is BLOCKED for a time. In this case all food irritating to the sensitive intestine must be avoided, while in constipation of the atonic type fibrous and even harsh foods may be helpful in stimulating the sluggish colon to greater activity.

It is of fundamental importance to distinguish between these two types of constipation in planning the diet. The simplest way to differentiate lies in finding out whether the constipation is AGGRAVATED BY or whether it is BENEFITED BY taking a good deal of FIBROUS food, especially that which contains fiber in the rougher forms.

High-residue Foods and Other Substances. It will be apparent from the table of high-residue foods on p. 363 that those especially to be featured in a diet for preventing or correcting **atonic constipation** are the DRIED FRUITS and LEGUMES, SEEDY FRUITS and those whith skins, coarse fibered and LEAFY VEGETABLES (especially raw). All fruits and vegetables contribute needed minerals and vitamins along with some fiber. Whole grain breads and cereals are also very useful, not only because of their fiber content but also because they are among the best sources of B vitamins, especially thiamine. Nuts are also favorable foods to use in atonic constipation, as they are rich in both fiber and thiamine.

Although **bran** is not to be considered as a food, its cellulose content is so high that, WHEN IT IS WELL TOLERATED, it is especially useful for certain types of constipation. Some of the softer cellulose in tender fruits and vegetables may be digested by bacteria and absorbed, but the fiber of the outer coats of grains is especially resistant to digestion and stimulating to the intestine. Bran may be sprinkled on breakfast cereal or used in bran muffins. The use of bran may easily be overdone and is best limited to obstinate cases of constipation where the intestine is sluggish and insensitive and the need for fiber may be unusually high.

Agar-agar is a shredded preparation of cellulose from seaweed, which is especially useful to ADD BULK to the feces and to keep them SOFT, since it is indigestible, takes up water and swells to form a soft, gelatinous mass. It should be used in all cases where some extra substance is needed to give bulk to intestinal residues, yet the digestive tract is too sensitive to admit of giving any harsh, irritating material or food. Such conditions occur in spastic constipation, colitis, gastric or duodenal ulcer. In these cases, a

TABLE XXIII. HIGH-RESIDUE FOODS IN ORDER OF CELLULOSE CONTENT

Fruits.	Vegetables.	Grain products.
Dried fruits:	Dried legumes (with skin):	*Bran*
Figs	Beans	Shredded wheat biscuit
Dates	Peas	Triscuit
Apricots	Lentils	Graham crackers
Prunes	Green peas	Oatmeal or cut oats
Raisins	Navy or lima beans	
Seedy fruits:*	Corn	
Huckleberries	Parsnips	Corn meal or hominy
Raspberries	Turnip	
Cranberries	Vegetable oyster	Whole wheat bread
Currants	Kohlrabi	Graham bread
Gooseberries		
Peaches	*Raw:*	
Pears especially if	Cabbage	Other whole grain cereals:
Plums skin is eaten	Tomatoes	
Grapes	Carrots	Wheatena
Apples	Onions	Cracked or flaked wheat
Strawberries	Celery	Wheatsworth
Cantaloupe	Cucumber	Pettijohn's
Oranges	Lettuce	Graham mush
Lemons	*Cooked:*	Puffed wheat
Grapefruit	Asparagus	
Rhubarb	Beets	
	Carrots	
	Cauliflower	
	Cabbage	
	Brussels sprouts	
	Spinach	
	Tomatoes	
	Onions	
	String beans	
	Potatoes, especially sweet	

* All except blackberries, which are constipating. Huckleberries are especially laxative.

soft, nonirritating diet is imperative; whole grains are prohibited, and fruits and vegetables are often limited in amount, so that intestinal residues may be too small to secure satisfactory laxation without use of agar-agar. It may be taken with water or fruit juice, sprinkled on cereal, or made into jellies similar to those made with gelatin (one fourth ounce will solidify a quart of liquid). Usually a few tablespoonfuls will suffice but larger amounts do no harm. Agar-agar is often preferable to bran, even in cases

of atonic constipation, because it can be taken in larger quantities with no ill effects. Psyllium seed is another nonirritating, indigestible substance that is sometimes used.

Foods Which Ferment. While a high cellulose content of the diet is the greatest single factor in combating constipation, certain other dietary factors can also be made to add their influence in promoting intestinal elimination. Among these is the use of certain foods which tend to ferment slightly in the intestine. These act in two ways—(1) the gases formed permeate the fecal material in many minute bubbles, thus breaking up the solid mass and making it of greater bulk and soft, foamy consistency, and (2) the other products of fermentation (acids, etc.) tend to keep down the growth of putrefactive bacteria and also have a slight stimulating effect on the intestinal movements.

Foods that have this effect are honey, molasses, corn sirup, marmalades, jams and preserves, malt sugar, milk sugar, or dextri-maltose. The sweets are best eaten with whole grain breads, and the preparations of malt or milk sugar added to fruit juices or milk. Too much sweets, especially those made with cane sugar, should be avoided as disturbing to digestion. A few vegetables such as onions, cauliflower and spinach, are apt to produce slight intestinal fermentation.

Yeast, when eaten in the uncooked state (live cells), will produce soft, bulky intestinal residues, frothy with gas bubbles formed in the fermentation which it sets up. However, it should be used only under a doctor's direction and one should remember that only when yeast cells have been killed by heat treatment will they give up their rich quota of B-complex vitamins. If the effect of the B-vitamins in combating constipation is desired, it is better to take the DRIED brewers' yeast or wheat germ.

Use of High Fat Diets. For some people, the presence of undigested fat in the intestine acts as a LUBRICANT, while the FATTY ACIDS produced in the digestion of fat stimulates the muscular movements of the intestine. For such persons, a diet which contains liberal amounts of fat has a laxative effect. Other individuals, however (and these probably in the majority), either digest fats so well that their lubricating effect is lost before they reach the intestine, or experience intestinal upsets due to a high fat diet. The latter type are likely to develop diarrhea alternating with spastic constipation, when they eat large amounts of fats. This is due to the irritation of the intestinal mucosa caused by the fats and fatty acids. But the high fat diet is undoubtedly of benefit in special cases, usually where the digestion of fats is not too good and the intestine not too sensitive.

Fats are best taken in the form of cream, butter, salad dressings or bacon.

As warm, visible fat is unappetizing, it is recommended that the fat be given either very hot or very cold, and incorporated in such foods as cream soups, cocoa, mayonnaise dressing, eggnogs or ice cream. Some people can beneficially take one or two tablespoonfuls of salad oil before breakfast or at night.

Use of Mineral Oil or Paraffin Preparations. MINERAL OIL formerly was recommended and had wide use as a lubricant for relief of constipation. Although it has a greasy feel, this oil is NOT A FAT and hence remains unattacked by the digestive fluids in its passage through the alimentary tract; it may be described as a sort of fluid paraffin which has no food value but facilitates the passage of hard, dry fecal material.

The use of mineral oil is now discouraged, since it has been found to selectively dissolve fat-soluble vitamins and the precursors of these vitamins found in foods. When the oil is excreted in the feces, these essential nutrients are carried along with it. It also interferes with the absorption of certain mineral elements. Its use along with food is hence no longer countenanced[7] and the incorporation of it in commercial foods such as salad dressings for reducing diets, is forbidden. Doctors still prescribe it for occasional relief from constipation, but caution that it should be taken as far as possible from mealtime, *e. g.*, the last thing before retiring, and the same applies to combinations of mineral oil with agar-agar in constipation remedies. The danger of nutritional deficiencies resulting from use of mineral oil occurs when it is taken regularly over long periods.

Numerous solid PARAFFIN preparations are also on the market for use in constipation, designed to have a lubricating effect when fluid at body temperature and to add some bulk to the intestinal residues. The same precautions apply to the use of such preparations as to mineral oil.

Laxative Effect of Fruit Acids and Water. WATER is one of the best LUBRICANTS, provided enough of it is taken so that it is not all absorbed from the alimentary tract. It is useful in keeping the fecal material soft whenever it is taken, but probably the greatest laxative effect is obtained from taking 2 glasses of water (or more), either alone, with acid fruit juice, or with a small amount of salt added, immediately on rising and at least a half-hour before breakfast. Such an early morning dose of fluid is apt to pass quickly along the alimentary tract flushing it somewhat and, in conjunction with the breakfast, stimulating the colon to its normal afterbreakfast evacuation. The dilute salt solution will not be absorbed to so great an extent as plain water; the acid fruit juice is suggested because fruit acids are

[7] Council on Foods and Nutrition of the American Medical Association, in J.A.M.A. v. 123, p. 967, 1943, and subsequent findings.

themselves mild stimulants to the peristaltic movements of the intestines; some people get good results by taking the water hot or cold, but it is probably best at about body temperature.

One large or two small glasses of undiluted orange juice on rising or just before breakfast are often very helpful in constipation, or the more acid lemon juice may be used in diluted form. Many people tolerate FRUIT JUICES best when taken alone, rather than with meals, and when no sugar is added. If it is desired to make them the carriers of some fermentable substance in combating putrefactive bacteria in the intestine, some of the less sweet and less readily fermented forms of carbohydrate, such as milk sugar, dextrin or dextri-maltose, should be used instead of cane sugar, as they not only produce better results but are less cloying to the taste and less upsetting to digestion.

All of the ORGANIC ACIDS, such as those contained in the citrus fruits, berries, grapes, apples, plums, rhubarb, and tomatoes, are mild stimulants to bring about INCREASED PERISTALTIC MOVEMENTS of the alimentary tract. Acid fruits are especially useful in overcoming a tendency to atonic constipation for this reason, as well as for the fiber that they carry and for the fermentable sugar that they contain. People with spastic constipation frequently cannot take the more highly acid fruits and vegetables, though sometimes milder ones like prune juice or even diluted orange or tomato juice, are well borne. Fruits should be used as liberally as feasible, either for breakfast, as salads or as desserts. Some people find the taking of fruit (or fruit juice) just before retiring beneficial in constipation, but others do not tolerate fruits well at night.

Diet in Spastic Constipation. While LOW-RESIDUE FOODS of SMOOTH BLAND nature (see table on p. 367) constitute a large part of the diet in constipation of the **spastic** type, one must use every opportunity to introduce SOME **fiber in softer forms.** Raw fruits or vegetables, those toughened by drying, those with hulls, skins or seeds, old or woody vegetables, acid fruits and much fatty food are not well borne by people with spastic constipation. Juice or pulp of the milder fruits, strained pulp of cooked vegetables and fruits, and a few of the less fibrous vegetables (cooked but unstrained) are the best forms in which to give fiber.

Usually whole grain products are not tolerated, though sometimes they are if flour is very finely ground or cereals are thoroughly cooked and strained. So-called "entire wheat" flours are obtainable from which the bran has been removed in milling, but which retain the germ rich in B-complex vitamins. They are often mixed with 50 per cent white flour in bread. If NO whole grains can be taken most of the highly milled (white)

SUMMARY

Diet for Constipation

Spastic type

Smooth, bland foods

- Milk
- Eggs
- Tender meats
- Cream soups
- Well-cooked cereals
- Bread and toast
- Simple desserts

Fiber in soft forms

- Stewed fruits, mild ones eaten without skins or seeds
  - Apples, Prunes, Pears, Apricots, Peaches
- Juices or pulp of mild, raw fruits
  - Oranges, Peaches, Melons, Bananas
- Milder vegetables, cooked (puréed or strained, if necessary)
  - Potatoes, Spinach (young), Asparagus tips, Cabbage ("), Cauliflower, Carrots ("), Broccoli, Beets ("), Tomatoes (cooked), String beans (")

Atonic type

Foods which stimulate intestine

- Acid fruits
- Acid or fermented milks
- Foods which ferment
  - Sugars
  - Honey, jams and sirups
  - Uncooked starch
- Foods rich in fat
  - Cream and cream soups
  - Cocoa or egg nog
  - Salad dressings
  - Ice cream, etc.

Fiber in harsher forms

- Fruit—especially
  - Raw fruits
  - Dried fruits, raw or cooked
  - Seedy fruits, and those eaten with skin on
- Raw vegetables
  - Lettuce, Radishes, Celery, Tomatoes, Cabbage, Carrots, Cucumbers, Onions
- Harsher vegetables, cooked
  - Beans, Peas (especially dried), Kale, Chard, Greens, Corn, Spinach, Parsnips, Brussels sprouts, Turnip, Vegetable oyster, Onions, Kohl-rabi
- Other vegetables and salad greens
- Whole grain breads and cereals

bread and cereals used should be of the "enriched" variety. In addition, some B-complex concentrate (in fluid, tablet or capsular form) may be needed and taken with advantage.

Vegetables like spinach may sometimes be tolerated, provided they are finely chopped or made into a smooth purée; some who do not think it possible, could take a few tender leaves of lettuce, if thoroughly chewed. Meats or tender beets and carrots may need to be finely chopped. Every effort should be made to take fiber in whatever forms are possible, and small amounts taken not too close together will often be well tolerated

when larger amounts or more frequent use would cause trouble. Persons with spastic constipation vary a good deal in their tolerance for different foods. As the intestine becomes less sensitive through treatment and limited diet, the diet may gradually be made more liberal by introducing from time to time small amounts of some previously denied foods, but those which are known to be very harsh or irritating should be permanently avoided by persons with a sensitive intestine.

If more bulk is needed than can be given in the food, *agar-agar* should be taken (as directed on pp. 362–3) in amounts required to produce normal bowel movements. Strong cathartics should be avoided in spastic constipation.

The table on page 367 gives the sharply contrasting diets used for correcting the two kinds of constipation.

QUESTIONS AND PROBLEMS

1. What two products of metabolism are excreted through the lungs? Explain how, in the functioning of the lungs, it is possible for these two substances to pass from the blood into the air that is expired. When a man exercises, there is increased oxidation of fuel foodstuffs and hence increased production of carbon dioxide. How is this sudden excess of carbon dioxide excreted?

2. What is the chief product of metabolism excreted through the skin? What other substances are present in perspiration? After occurrence of profuse perspiration, why is it advisable to take not only plenty of water but small amounts of salt (sodium chloride)?

3. What waste products are excreted through the kidneys? Explain the mechanism by which the kidneys secrete urine. In a normal person, what conditions will cause an increased or a decreased output of each of the following in the urine—water, urea, sodium chloride, ammonium salts? Is urine normally acid or alkaline, and what will cause its reaction to vary?

4. What is meant by the water balance of the body? Explain how the body is normally kept in equilibrium as to its water content.

5. What are the main constituents found in the feces? Which of these may be described as residues (or debris) from the contents of the digestive tract, and which are true waste products of metabolism? Describe the mechanism that leads to defecation and outline the chief causes of constipation. Distinguish between the atonic and spastic types of constipation.

6. Write a day's menus suitable for a person with atonic constipation, and another set of menus suitable for a person suffering from constipation

of the spastic type. Suggest changes in living habits or any other procedures that might be helpful for each of the two types of constipated persons. What are the criteria for deciding whether a person is constipated?

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PART

4

MEAL PLANNING

CHAPTER 21

HOW TO BUILD MENUS—FOR A DAY

ALMOST all of us have a vital interest in the planning of meals. To the HOUSEWIFE, it is that part of her duties upon which the welfare and happiness of her family is most directly dependent. To the AVERAGE MAN, securing appetizing and satisfying meals is one of the comforts and pleasures of life, and moreover, it is a pleasure that promotes and is intimately associated with much enjoyable and stimulating social intercourse. To the CHILD, the diet is of even greater importance than to the adult, for the extremes of a good or poor supply of body building material during the growth period mean the difference between a stunted, poorly developed body, which has little strength and great susceptibility to disease, and a relatively large, well-developed body with abundant vitality and high resistance to disease. With every individual, an adequate and well-balanced diet is one of the fundamental requirements for securing health, and health in turn is fundamental for happiness.

THE PROBLEM OF PLANNING ATTRACTIVE MEALS IS THE CRUX OF THE PROBLEM OF GETTING PEOPLE TO TAKE THE FOOD WHICH IS GOOD FOR THEM AND AT THE SAME TIME TO ENJOY IT. Appetite and the mental states which go with the enjoyment of food make for good digestion and assimilation of food. Therefore, the planning of attractive combinations of food, with the proper cooking and serving which go to make an enjoyable meal, are not beneath the dignity of anyone or undeserving of the attention which we will devote to them in the following pages.

Every meal-planner has to meet special problems and unexpected emergencies in planning the daily dietary, so that the tendency to give or to follow set schemes and arbitrary rules is to be discouraged. In spite of the fact that menus prepared by somebody else seldom fit individual family needs, those published in newspapers and magazines are of interest in that they suggest variety to the housewife or special ways of serving foods that are plentiful. They are useful for suggestions but need adapting to individual cases. The aim in this and the following chapter is to provide the reader with certain GENERAL rules, which should be kept in mind in

planning meals, so as to assure both ATTRACTIVE food combinations and a diet ADEQUATE to meet the body needs. The menus given merely show a few examples of how these meal-planning principles might be applied in practice.

It should be emphasized that these chapters are written to meet the needs of NORMAL ADULTS. Dietaries for children and for special conditions are considered elsewhere.

Difference between Adequate and Optimal Diet and How to Secure Each. By an ADEQUATE diet we mean one that will maintain body weight (and provide for growth if necessary) and keep the body in a moderately satisfactory state of health.

An OPTIMAL diet is one that will promote maximum growth and a high degree of vitality and resistance to disease.

There is a wide zone between these two types of diet. Most of us get a food supply which is at least adequate to meet our actual physiological needs, but there are probably few whose bodily welfare could not be improved by taking more of those foods whose inclusion in the diet tends to promote a state of positive health. McCollum calls these the "PROTECTIVE FOODS" and puts under this head MILK and the LEAFY VEGETABLES. We might stretch this classification to include the other vegetables, fruits and whole grains, foods whose inclusion in the diet also benefits health.

Sherman has shown that the addition of more milk to a diet considered already adequate, produced in experimental animals larger size, longer duration of the prime of life, a higher degree of health and of reproductive activity; the diet thus improved was rendered still more effective by the addition of a fresh green vegetable; and all of these improvements were even more noticeable in the second generation than in the first. These protective foods strengthen the diet at the points where it is most likely to be lacking, *i. e.*, they introduce extra amounts of MINERAL ELEMENTS and VITAMINS, while vegetables, fruits and whole grains also provide ROUGHAGE.

The best way to make sure of getting an optimal diet is to plan meals according to a **dietary pattern,** such as that suggested by members of the Food and Nutrition Board of the National Research Council and given in the table on p. 375. This dietary pattern was designed as a practical scheme for insuring plenty of mineral elements and vitamins in the diet, as well as enough protein of high quality. It allows considerable leeway for differences in food habits and incomes. Higher income groups may use meat, eggs and butter more freely. Lower income groups will depend more on starchy foods and have a narrower choice of fruits and vegetables. But all will get an **adequate** diet, if they take each day at least the minimum

amounts of the foods called for. More liberal numbers of servings of fruits and vegetables, more frequent use of green, leafy or yellow vegetables, and of citrus fruits or tomatoes, larger quantities of milk, eggs or whole grains —all these are practices that tend to make the diet approach more nearly to OPTIMAL standards.

FOODS FOR EACH PERSON DAILY

DIETARY PATTERN:

Milk—1 pint for adults, 1½ pints to 1 quart for children
Vegetables—at least 2 liberal servings (besides potato), one of which should be green or yellow and one of which should frequently be raw
Potato—1 serving
Fruit—2 or more servings, one of which should be citrus fruit or tomato (or other good source of vitamin C)
Meat, poultry or fish—1 serving; beans, peas or nuts occasionally
Eggs—at least 3 to 4 per week (some recommend 1 daily, including those used in cooking)
Cereal or bread—most of it whole grain or "enriched" (usually 4–6 slices bread or equivalent)
Butter or "fortified" margarine—usually 2 tablespoons, or more
Additional starchy foods, fats, desserts and sweets, fruits and vegetables, varying in quantity according to the energy needs of different individuals.

How to Combine Foods in Menus. The problem is to provide the foods listed in the above table, as essential for each person to have daily, in the form of three meals which will be both suitable and attractive. The day's dietary should always be CONSIDERED AS A WHOLE, the meals should be planned ahead of time, and arranged so as to supplement each other. This is not only more economical of time and money, but insures better balanced and more attractive meals, and is the ONLY WAY OF BEING SURE TO GET IN THE FULL AMOUNT OF THE ESSENTIAL FOODS EACH DAY.

SOME GENERAL RULES FOR MENU-PLANNING

1. Use the **whole day as a unit** rather than the individual meal; have breakfast relatively simple and standardized, then plan dinner, and lastly plan luncheon (or supper) so as to supplement the other two meals.
2. Use some food from **each of the food groups** (carbohydrate foods, protein-rich foods, fatty foods, fruits and vegetables) daily and usually in each meal.
3. Use some **raw** food at least once a day.
4. Plan to have in every meal at least one food which has **staying quality** or high satiety value, at least one food which requires **chewing,** one which contains **roughage,** and generally some **hot** food or drink.
5. Combine (or alternate) **bland** foods with those of more pronounced **flavor.**
6. Combine (or alternate) **soft** foods with those **crisp** in texture.
7. Have **variety** in **color, form,** and **arrangement** of foods.
8. Alternate **simple** and less nutritious dishes with those which are richer, more nutritious and **harder to digest.**

9. When a greater number of foods are served at one meal, decrease the size of the portions and use fewer rich foods. When a more simple meal is desired, use a few nutritious, easily digested foods, and serve larger portions.

DONT'S FOR MENU-PLANNERS

1. Do not have a preponderance of **one foodstuff** in a meal.
2. Do not have many **rich** foods, or other foods which are hard to digest, in one meal.
3. Do not use the **same food twice in one day** without **varying the form** in which it is served, except staples like bread, butter, milk, etc.
4. Do not use the same food twice in the same meal even in different forms.
5. Do not use the same foods too constantly even from day to day.
6. Avoid **monotony** of **color, texture,** etc. in any one meal or in the daily dietary.

On page 377 are **menus** which are **poorly planned,** and examples of **how to correct these errors** in menu-planning. Each of the latter menus is numbered to correspond with the faulty menu which it is suggested to replace, and the attempt has been to make a more ATTRACTIVE and BETTER BALANCED menu, while retaining some of the key foods around which the meal was built. The reader is also asked to notice that the substitute menus contain MORE FRUIT, VEGETABLES and RAW FOODS than the original ones, so that they will be more wholesome as well as more palatable. Economy of preparation has also been taken into account—having a number of oven-cooked foods in one meal and other meals of the quickly prepared type. In some instances superfluous foods have been omitted and the menu simplified. Some of the foods which had to be dropped as unsuitable are used to advantage under different conditions in other menus. The significance of the changes needed to make good menus out of the bad ones is pointed out below:

(1) Protein-rich and highly nutritious soup dropped.
Protein-rich beans replaced by sliced tomatoes; lettuce salad added.
Protein-rich custard and macaroons left out and, as meal is being made less heavy, a medium rich but tasty dessert (apple pie) may be used instead.
Substitution of carbohydrate foods (potatoes, bread, etc.) for some of the protein.

(2) The candied sweet potatoes and fried vegetable replaced by baked potatoes and vegetable, which are more easily digested in this form.
The fat-rich, protein-rich tuna fish salad replaced by plain lettuce salad.
A light fruit dessert and simple cookies substituted for the rich chocolate dessert and cake.

(3) A more highly flavored soup, and one without thickening is used.
The starchy potatoes and lima beans are dropped out.
Cheese and tomato are used to give flavor to the casserole dish.
The soft cream spinach is replaced by the harsher plain boiled spinach.
A crisp salad of appetizing flavor is added to increase the palatability and round out the nutritive qualities of the meal.

Examples of Gross Errors in Menu-planning

(1) Too much PROTEIN.	(2) Too many RICH foods.	(3) Too many STARCHY foods, too little flavor, monotony in texture.	(4) Same food used twice, too highly flavored, poor color combination.
Split pea soup	Roast pork	Cream corn soup	Tomato bisque
Hamburger steak	Candied sweet potato	Baked potato	Roast beef
Baked beans	Fried eggplant	Casserole of rice with fish and lima beans	Browned potatoes
Bread and butter	Tuna fish salad (mayonnaise)	Creamed spinach	Buttered beets
Baked custard	Chocolate blanc mange with whipped cream	Indian meal pudding	Tomato salad
Almond macaroons	Cake		Raspberry ice
			Spice cake

(5) Monotony in texture.	(6) Monotony in color.	(7) No satiety value.
Beef broth	Omelette	Chicken soup
Creamed chicken	Sweet potato	Raw cabbage and pineapple salad
Mashed potato	Squash	Orange
Cauliflower (hearts)	Carrot and string bean salad	Tea
Floating Island	Lemon jelly	
Sponge cake		

Suggestions of How to Rectify These Errors

(1)	(2)	(3)	(4)
Hamburger steak	Roast pork	Beef broth	Tomato bisque
Boiled potatoes with parsley butter	Baked sweet potatoes	Casserole of rice with cheese and tomato	Roast beef
Sliced tomatoes	Stuffed eggplant	Spinach	Browned potatoes
Lettuce salad	Lettuce salad	Waldorf salad	Baked squash
Bread and butter	Apple sauce	Indian meal pudding	Lettuce salad
Apple pie	Cookies		Raspberry ice
			Sponge cake

(5)	(6)	(7)
Creamed chicken on toast	Omelette with asparagus	Cream chicken soup
Stewed celery	Creamed potatoes	Salmon salad with green peas
String beans	Raw cabbage salad	Bread and butter
Pineapple salad	Chocolate blanc mange with thin cream	Orange
Floating island	Cookies	Tea
Macaroons		

(4) A mild-flavored, baked vegetable (squash) replaces the beets.
The recurrence of tomato is prevented by using plain lettuce instead of tomato salad, which also makes the flavor and color of the salad course so much less noticeable that it is permissible to retain the highly-flavored red dessert, although a milder flavored cake is used with it.

(5) The mushy texture of the meal is improved by the omission of soup, mashed potato, cauliflower and the soft cake; and by the addition of foods which require chewing, in the toast, celery, string beans, salad and macaroons.

(6) The yellow sweet potato, squash, carrot and lemon jelly are dropped, while the inclusion of white potato, asparagus, raw cabbage and a soft chocolate dessert served with crisp cookies improves the flavor and texture of the meal as well as its color combinations.

(7) The more nutritious cream soup is used in place of plain chicken broth.
The satisfying and nutritious qualities of the meal are further improved by the addition of bread and butter, and by the substitution of the salmon and green pea salad for the one made of green stuffs and fruit.

SKELETON MENUS FOR THE THREE MEALS OF THE DAY

Breakfast.		Lunch (or supper).		Dinner.	
*Fruit Cereal Hot dish Bread stuff *Hot beverage	May omit 1 or 2 unstarred foods	Soup (or appetizer Hot dish with vegetable Salad Dessert Beverage	May omit any 1 or 2	Soup (and/or appetizer) Entrée (or fish) *Meat course with vegetables Salad *Dessert Beverage (and/or post-dessert dainties)	May omit any 2 or 3 unstarred courses.

The **types of dishes** which are combined to make a meal are not the result of chance, nor is the **order in which the foods are served** merely a matter of convention. Instinct seems to have guided man in selecting foods which supplement each other so as to give a fairly well-balanced meal, and in serving the various dishes he has followed the order which is most favorable from the standpoint of digestion and satiety value. For instance, at dinner first comes the SOUP, which has low satiety value and stimulates the flow of digestive fluids in the stomach. Then the ENTRÉE, if served, should be a relatively light food, because it reaches the stomach before the secretory activity of this organ has reached its height. Next comes the MEAT course, which makes the greatest demand on the digestive powers

of the stomach and arrives as the flow of digestive fluids is greatest. The meal is finished with an oily SALAD and the SWEETS, both of which have high satiety value but need little digestion in the stomach. Thus we see that the conventions decreed in menu-building have a physiological basis, and that following them is apt to make for greater ease of handling the meal in the stomach, as well as for that pleasant feeling of being well fed.

In the suggestions which we have to offer below for filling in skeleton menus (pp. 380–385), the reader is asked to notice the attempt to **balance the meal within itself,** and, more important still, to **balance the day's meals against each other.** In this respect there should be special care

(1) to use foods from EACH of the different FOOD GROUPS (starchy foods and sweets, fatty foods, protein-rich foods, milk or milk products, fruits, and vegetables);
(2) to use PROTEIN-RICH and FAT-RICH foods with MODERATION;
(3) to include BASE-FORMING foods liberally (see p. 85);
(4) to provide an EXCESS of MINERALS and VITAMINS;
(5) to include sufficient HIGH-RESIDUE foods.

The last three specifications are best met by giving milk, fruits, and vegetables a prominent place in the diet and by including some whole grain products. The general rules for menu-planning given on p. 375 should also be observed so as to secure pleasing combinations of flavor, texture, color, etc.

Finally, in balancing one meal against another in the day's rations, it is well to bear in mind—

(1) that if one meal is very HEAVY, the others should be correspondingly LIGHT;
(2) that one meal SUPPLEMENTS another in some respects—
BREAKFAST is usually a starchy meal,
DINNER is the high-protein meal,
LUNCH or supper holds the "balance of power," and, while usually it is best not a high-protein meal, it should be planned to round out the day's rations;
(3) that all the ESSENTIAL foods (as given on p. 375) should be worked into some of the three meals.

The reader should be cautioned, however, that, important as MENUS are from the **qualitative** viewpoint, they do not tell anything about the **quantitative** consumption of food. Everything depends on the size of the serving, and on whether it is or is not completely eaten. Eating a generous serving of one vegetable will do more for the body than having three on the menu of which two are declined and a dab of the third consumed. Persons who eat at the same table will often show wide differences in the kinds and amounts of foods taken, as is evidenced by the widely divergent caloric

value of the two breakfasts cited below. The difference in caloric intake is due to slightly LARGER PORTIONS of the staple foods and to the more lavish use of MARGARINE, CREAM and SUGAR in the higher-calorie meal. Meals chosen from the same menu may vary considerably in protein, mineral and vitamin values.

Menu.	(1)		(2)	
Orange juice	6 oz.,	72 calories	8 oz.,	96 calories
Oatmeal (cooked)	⅓ c.,	53 "	⅔ c.,	105 "
with thin cream	½ c.,	104 "	½ c.,	208 "
and sugar			2 tsp.,	40 "
Toast	1 slice,	65 "	2 slices,	130 "
Margarine (fortified)	1 pat (10 gm.),	73 "	3 pats,	279 "
Coffee	1 cup		1 cup	
with sugar	1 tsp.,	20 "	2 tsp.,	140 "
and cream (thin)			2 tbsp.,	62 "
		387		900

The total amount of **fuel foods** consumed should be so gauged for adults that they **neither lose nor gain weight.** Persons who are above or below their normal weight should modify their food intake accordingly. All persons should see to it that they take their **daily quota** of **protective foods** (milk, fruits and vegetables, especially leafy vegetables). If these PRECAUTIONS are observed, the quantitative aspects of the food intake will largely take care of themselves and we can follow the slogan, "EAT WHAT YOU WANT AFTER YOU HAVE EATEN WHAT YOU SHOULD."

HOW TO FILL IN SKELETON MENUS

Breakfast. This is essentially an unsocial meal, but SHOULD NOT BE HURRIED OR OMITTED. Whether it is LIGHT or HEAVY will depend upon the habits and activity of the individual. Sedentary people generally do not need a heavy breakfast and the old-fashioned breakfast with meat, potato, pie or doughnuts on the menu is fortunately a thing of the past in this country, though we still eat more than the light breakfast which Europeans take. The practice of beginning this meal with FRUIT is beneficial both for its laxative effect and as an appetizer. A HOT BEVERAGE (usually coffee) is also helpful to most people in starting the day. Hence we advise the inclusion of fruits, some staying food and a hot drink in every breakfast menu. The rest of the meal may be made more or less elaborate, according to the needs of the family, as follows:

Light.	Moderate.	Moderately heavy.	Heavy.
Fruit Breadstuff Hot beverage	Fruit Cereal Breadstuff Hot beverage	Fruit Cereal Hot dish Breadstuff Hot beverage	Fruit Cereal Hot dish Second hot dish Breadstuff Hot beverage

We may fill in the above skeleton menus to make the following breakfast menus:

Light.	Moderate.	Moderately heavy.	Heavy.
Grapefruit (half) Toast (with jam) Coffee	Banana (half) Oatmeal with top milk) Toast (with marmalade) Coffee	Orange juice Puffed wheat (with top milk) 1 boiled egg Bacon Corn muffins Coffee	Baked apple with cream Cream of wheat (with top milk) Sausages Griddle cakes (with syrup) Toast Coffee

Luncheon (or Supper). The size and character of this meal will vary a good deal with different individuals and families. In general if the breakfast is very light, a fairly substantial luncheon should be taken, though some people prefer to eat a moderately light luncheon and make up on a heavier dinner. Persons who are PHYSICALLY ACTIVE need a staying meal at noon, but those who must eat HURRIEDLY or who will be engaged in MENTAL WORK during the afternoon will do well to eat a light lunch. However, the practice common to city workers of taking merely a sandwich and coffee at noon is not to be recommended, as it may lead to malnutrition and to exhaustion in the late afternoon.

For the reason that TOO MUCH FOOD and TOO MANY PROTEIN-RICH FOODS are apt to be eaten if luncheon is made an elaborate meal, **it is best kept a simple meal** which is made up mainly of CARBOHYDRATE FOODS, FRUITS and VEGETABLES. It may well include nourishing cream soups, light dishes made from leftovers, an egg or cheese dish, vegetables, salads, simple desserts or fruit. It is better to AVOID the use of meats, fish or poultry in this meal, except as small amounts are used in warmed-over dishes or to flavor bland foods. Both soup and desserts used with luncheon or supper may be somewhat richer than those included in the dinner menu.

Dinner should be served at noon for children, invalids, and some adults who find a heavy meal at night disturbs their digestion and sleep. In such cases, **supper** should consist of SIMPLE, EASILY DIGESTED foods, but should contain enough staying and nourishing foods to round out the day's food supply and to enable one to go until morning without hunger. Too light a supper is a common dietary error in some districts, and the meals would be better more evenly divided. Much the same kind of dishes are suitable for supper as for luncheon, but it should generally be a little less elaborate a meal, and children especially should have only easily digested foods at night.

Luncheon menus are given below. The type of menus that may be designated as LIGHT or MODERATE are to be recommended for most persons in preference to the more elaborate or heavier meal plans. The one designated as HEAVY offers an example of the FORMAL LUNCHEON, such as is often used in entertaining.

The following meal plans are illustrative of how lunch may be varied from a simple to an elaborate meal:

Light.	Moderate.	Moderately heavy.	Heavy.
Soup	Hot dish with vegetable	Soup	Appetizer
Salad	Salad	Main dish with vegetables	Soup
Dessert	Dessert	Salad or dessert	Main course
		Beverage	Salad
			Dessert
			Beverage

By filling these in with suitable foods we make the following luncheon menus:

Light.	Moderate.	Moderately heavy.	Heavy.
Cream of green pea soup	Omelette	Vegetable soup	Oyster cocktail
Apple, celery and nut salad	Creamed cauliflower	Creamed fish	Consommé
Bread and butter	String bean salad	Beet top greens	Chicken à la King
Pineapple tapioca pudding	Graham muffins	Beets	Stuffed potatoes
	Applesauce (or fresh fruit)	Gingerbread	Asparagus au gratin
		Milk	Rolls
			Fruit salad
			Maple mousse
			Small cakes
			Coffee

When lunches must be eaten away from home, choice is more limited and hot dishes may be harder to obtain. Sandwiches with nourishing filling may have to be the mainstay, with milk or a hot beverage and desserts like fruit, ice cream or simple cookies. Other good combinations obtainable at restaurants or school lunch rooms are—hot, nourishing soup, a salad, bread and butter, simple pudding or other nutritious dessert; hot dish (such as macaroni and cheese) with one vegetable, milk to drink, fruit and cookies. Such a lunch should be planned to include enough high energy foods to carry one through the afternoon activities without fatigue and also some of the day's quota of essential foods, such as milk, fruit and vegetables. The writer feels strongly that the inclusion of some hot food or drink favors digestion.

Dinner. This is essentially the **social** meal and the **meat** meal of the day. As such, it is best taken at night by most adults, because of the greater leisure after the day's work is over. However, it should not come TOO LATE in the evening nor be made an excessively RICH and ELABORATE meal (*e. g.*, so-called "banquets"), for in such cases digestion is apt to be poor and the night's rest disturbed. It is inadvisable to eat within two or three hours of the time of retiring. Only LIGHT DESSERTS should be used at dinner, and fresh fruit makes the very best dessert for this meal. CLEAR SOUPS and meat broths, which contain little nourishment but are stimulating to the flow of gastric juice, are best used at dinner, while cream soups and vegetable purées are kept for luncheon or supper dishes. Fruit or vegetable juices, fruit or seafood cocktail, or other "appetizers" may precede the soup course. Convention originally confined the use of HORS D'OEUVRES (cold "appetizers") to the opening course at luncheon and decreed that they should be served in place of, and not in conjunction with soup, but their use at dinner before the soup course is now quite common. The SALADS used at dinner are also best of the simple type and free from rich dressings, since the heavier meat course should form the bulk of the meal in order not to overtax digestion. Menus which contain relatively FEW COURSES are to be recommended instead of the more elaborate meals.

Skeleton menus, which show how dinner may be made a relatively light or heavy meal, are given on the following page.

Light.	Moderate.	Moderately heavy.	Heavy.
Meat course Salad Dessert	Soup Meat course Salad Dessert	Soup Relish Meat course Salad Dessert Beverage	Appetizer Soup Entrée Meat course Salad Dessert Beverage and after dessert dainties

Suggestions as to how these menus might be filled in, are as follows:

Light.	Moderate.	Moderately heavy.	Heavy.
Broiled ground steak (or meat loaf) Boiled potatoes Creamed onions Lettuce and tomato salad Prune whip Cookies	Scotch broth Baked bluefish Baked potatoes Baked yellow squash Half-pear garnished with raisins Caramel custard Plain cake	Cream asparagus soup Radishes and olives Roast lamb (with brown gravy) Browned potatoes Carrots and peas Mixed green salad Spanish cream with chocolate sauce Tea or coffee	Half grapefruit Bouillon Crab meat patties Roast duck (with apple sauce String beans Escalloped corn Shredded cabbage, celery and pineapple in gelatin mold Pistachio ice-cream Lady fingers Coffee Cheese and crackers

Combining Meals in the Day's Ration. THE THREE MEALS OF THE DAY SHOULD BE PLANNED AT THE SAME TIME, keeping the character of the other two meals in mind as each one is planned and following the general rules for menu-building given on p. 375. However, to save time and space, as well as to illustrate what types of meals tend to supplement each other, we will take the meals already given above and arrange them in such combinations as might be fairly satisfactory for a day's ration. The fourth menu is discarded in each case as too heavy to be recommended. The reader is urged to turn to the general rules for balancing menus within the meal and for balancing the three meals of the day against each other (p. 379); he should then study the menu-combinations presented on p. 385 to see

whether and HOW they meet the various requirements for satisfactory meal groupings in a day's ration. Bread and butter (or margarine) are assumed available at any meal, and beverages may be varied or added, as desired. ANY OF THE DAILY QUOTA OF MILK NOT USED IN OR ON THE DAY'S FOODS SHOULD BE TAKEN IN THE FORM OF BEVERAGES—cold, hot in coffee or coffee substitute, in cocoa, as buttermilk, etc.

The following combinations of the meals given above are suggested as suitable:

(1)	(2)	(3)
Light breakfast Moderate lunch Moderately heavy dinner	Moderate breakfast Moderately heavy lunch Light dinner	Moderately heavy breakfast Light lunch Moderate dinner

This would make three sets of menus, each covering the meals for one day, which read as follows:

(1) Breakfast.	(2) Breakfast.	(3) Breakfast.
Grapefruit Toast with jam Coffee	Oatmeal with sliced banana Toast Marmalade Coffee	Orange juice Puffed wheat 1 boiled egg Bacon Corn muffins Coffee
Luncheon.	**Luncheon.**	**Luncheon.**
Omelette Cream cauliflower String bean salad with French dressing Graham muffins Applesauce (or fresh fruit)	Vegetable soup Creamed fish Beets Beet top greens Gingerbread Milk	Cream green pea soup Apple, celery and nut salad Bread and butter Pineapple tapioca pudding
Dinner.	**Dinner.**	**Dinner.**
Cream asparagus soup Radishes and olives Roast lamb with brown gravy Browned potatoes Carrots and peas Mixed green salad Spanish cream with chocolate sauce Tea or coffee	Broiled ground steak (or meat loaf) Boiled potatoes Creamed onions Lettuce and tomato salad, French dressing Prune whip Cookies	Scotch broth Baked bluefish Baked potatoes Baked yellow squash Half pear salad, garnished with raisins Caramel custard Plain cake

QUESTIONS AND PROBLEMS

1. Why is menu planning important? What should be the unit for planning menus—the meal, the day, or the week? Why? In what respects is menu planning a science and in what respects is it an art?

2. Give a list of the foods, and quantities of each, which should be included in the diet in some form each day in order to assure an adequate diet.

3. Tell in what respects the following menu is faulty and make suggestions by which it may be improved:

Cold sliced salami sausage
Potato salad
Crackers and cheese
Apple pie
Beer

4. Plan a day's menus for a moderately active college student, who should have a fairly hearty breakfast, a moderate lunch, and a hearty dinner (see the skeleton menus in preceding chapter). Check these menus with the list of essential foods, and rules for menu-making given on pp. 375–376.

5. Make a day's menus for a young married couple, both of whom work and eat lunch away from home. Plan for a moderately hearty breakfast and dinner, which are quickly prepared, but keep food costs as moderate as is consistent with providing adequately for their nutritional needs.

6. Plan the day's meals for an elderly and sedentary couple, who eat a light breakfast, main meal in middle of the day, and a simple supper. Food costs may be more liberal in this case.

SUPPLEMENTARY READING

Gillett, Lucy H., NUTRITION IN PUBLIC HEALTH, Chap. V, "The Family Meals," pp. 103–137, W. B. Saunders Co., 1946.

Rose, M. S., FEEDING THE FAMILY, 4th ed., Chap. IV, "The Making of Menus," pp. 70–88, The Macmillan Co., 1940.

Rountree, Jennie I., "This Problem of Food," Public Affairs Committee, Inc., 30 Rockefeller Plaza, New York, 1940.

CHAPTER 22

HOW TO BUILD MENUS—FOR A WEEK

IN THIS chapter we shall treat the following aspects of the problem of menu-building: (1) how to introduce variety from day to day; (2) how to utilize left-over foods; (3) how to effect economy of labor in preparing meals.

Variety. This is the phase of menu-planning most troublesome to the housewife. She can plan an elaborate meal for occasions, which will win praise from all who partake of it, but her versatility is not equal to the strain of concocting 21 good meals per week and doing so on a reasonable cost basis. Those who eat in hotels, restaurants, schools or other institutions can testify to the monotony of the diet served in these establishments. One is almost persuaded that there ARE only five kinds of meat and six vegetables, so seldom are the other varieties met with on the table. The use of a wide range of foods is one of the best ways of assuring that the diet will meet all of the body needs. Broadly speaking, THE GREATER THE VARIETY OF FOODS USED FROM DAY TO DAY THE BETTER FOR GENERAL HEALTH, BUT THE LESS THE NUMBER OF FOODS SERVED AT ANY ONE MEAL THE BETTER FOR DIGESTION (and the easier it is to secure day-to-day variety).

Variety in Breakfast. Variety seems less essential in breakfast than in the other meals. Many persons eat breakfast rather hurriedly and with their minds intent upon other things. Hence they are content to have a simple and fairly standardized meal. Some people, however, crave variety in this meal, either to tempt their appetite or because they are accustomed to making a more elaborate meal of breakfast. The following **ways of making changes in breakfast** may be suggested: by varying (1) the TYPE OF MAIN DISH served, (2) the FRUIT, (3) the CEREAL, or (4) the BREADSTUFF used; (5) by cooking EGGS IN DIFFERENT WAYS; and (6) by serving DIFFERENT BEVERAGES. How the breakfast menu may be altered by varying the elaborateness of the meal has already been taken up on p. 381. If this meal is kept simple, its character may be much altered according to the types of foods served—*e. g.*, replacing toast or muffins with a breakfast cereal or eggs; substituting such foods as cod-fish balls, minced meat on toast, liver and bacon, etc., for eggs.

FRUITS. Almost any fresh fruit which is in season may be served for breakfast, and in addition canned fruits or stewed dried fruits are available for use when fresh fruit is scarce or too costly. The citrus fruits are especially valuable for their vitamin content and appetizing qualities and are on the market now at reasonable prices almost all the year. Canned fruit juices (or tomato juice), whose flavor and vitamin content are little impaired by the canning process, are also available at moderate cost.

CEREALS. A large number of breakfast cereals is available to choose from. Needless to say, the use of whole grain preparations is to be recommended, but others are useful for variety, and especially for children or for persons with sensitive intestinal tracts who do not tolerate whole grains well. If highly milled cereals are used, those that have been "enriched" with B vitamins and iron should be given preference. While the ready-to-serve preparations are convenient, they are much more costly, in proportion to the nutritive value which they furnish, than the cereals which require cooking.

The use of cereal at breakfast offers one of the best ways of introducing milk into the diet. (Top milk on cereal is more wholesome than thick cream, as well as much more economical.) Cereals are also a good dish for children's SUPPERS and combining fruits with cereals from time to time makes a pleasing note of variety, as well as a way to introduce fruit into the diet.

BREADSTUFFS. These need only be suggested—the use of whole wheat bread for toast instead of white bread (greatly to be recommended); the occasional use of small breads such as rolls, biscuits, muffins, gems, coffee cakes, tea cakes, scones, griddle cakes and waffles, and the use of different flours in making muffins, griddle cakes, etc. (*e. g.*, oatmeal, corn, rice, whole wheat or bran muffins; wheat, buckwheat and corn griddle cakes). In the South, hominy grits are often served for breakfast, plain or fried, along with egg or meat dishes. Griddle cakes and waffles, as well as doughnuts and cookies, should be used sparingly as breakfast dishes and not allowed to replace essential foods or to make the meal too heavy. Jams, jellies, and marmalades should also be used with moderation, so as not to sate the appetite for the essential foods by taking too much sweet.

WAYS OF COOKING EGGS. Properly cooked eggs are more easily digested than raw eggs. Care should be taken to avoid two errors in cooking, which render them less digestible—namely, cooking at high temperature so that the white has a leathery texture, and using so much fat that the product is greasy. Poached eggs are apt to be flat-tasting and watery. If skilfully cooked, fried eggs may be excellent. Scrambled eggs, omelette and shirred

eggs may also be spoiled, if cooked in such a way as to be greasy. Boiled eggs are best cooked a medium length of time, and in water which is kept hot but below boiling point.

Although relatively expensive, eggs also make excellent dishes to serve at LUNCHEON or SUPPER and the more fancy forms of cooking them (special omelettes and soufflés) will be found under that head. They should not, however, be served twice in the same day, except for their supplementary use in cooking. Their acid-forming effect needs to be offset by using plenty of milk, fruits and vegetables, but they are listed as a desirable food to include in the menu fairly frequently because of the high quality protein, mineral salts and vitamins which they provide.

Variety in Luncheon or Supper. This is generally accounted the most difficult meal to plan, although it should not be hard to secure variety in it since it is the meal PAR EXCELLENCE for using up LEFT-OVERS of all sorts of foods. The chief trouble seems to be in planning a meal without the use of meat, or one which will not be too much like dinner. To meet this difficulty the use of some dish made with MILK, EGGS, or CHEESE is strongly to be recommended, as well as serving some succulent VEGETABLE or SALAD in this meal, since both of these practices make for the desired variety and at the same time help to work in the ESSENTIAL foods which are often not used in optimum quantities for health. Salads are always appetizing, provide a way of putting needed raw foods into the dietary, and help make a meal which is satisfying without being too high in fuel value. SALAD IS THE BEST SINGLE DISH TO LEND ITSELF TO VARIATION. The more nourishing salads and soups may also be made the main dish in a simple meal like luncheon, while they are out of place in a dinner menu. More detailed suggestions as to types of food suitable to include in the luncheon menu follow, the reader being referred to standard cook-books for specific directions for making such dishes.

THICK SOUPS

Cream soups—cream chicken, mushroom, asparagus, artichoke, cauliflower, celery, knob celery, corn, green pea, onion, lettuce, spinach, tomato, barley, rice, potato, etc.

Purées—split pea, bean, lentil and other vegetable purées.

Chowders—clam, oyster, fish, corn, etc.

EGG AND CHEESE DISHES, ENTREES, ETC.

Eggs cooked in any of the ways suggested under breakfast dishes.

Omelettes—plain, aux fines herbes, Spanish, with ham, cheese, mushrooms, chicken livers, kidneys, rice, asparagus, green peas, tomatoes, etc.

—sweet ones, with jelly, marmalade, powdered sugar, etc.

Soufflés—savory—with cheese, chicken, fish, pumpkin or carrot as flavoring.
—sweet—vanilla, chocolate, coffee, caramel, almond, orange, lemon, apple.
Cheese dishes—cheese aspic, charlotte, casserole with celery, croquettes, fondue, loaf, rarebit or toast (both with tomato added if desired), soufflé.
Cottage or cream cheese—plain, or in salad.
Croquettes—chicken, egg, cheese, meat, potato, rice, sweetbread, mushroom.
Patties—chicken, crabmeat, lobster, etc.
Timbales—ham, tongue, chicken, sweetbread, and vegetable.
Mushrooms and sweetbreads.
Shellfish and other fish dishes.
Stuffed vegetables—vegetables such as tomatoes, eggplant and green peppers stuffed with meat mixtures, or with their own pulp mixed with cracker crumbs and seasoning.

Left-over Dishes and Other Luncheon Dishes

Starchy dishes—Macaroni, spaghetti, noodles and rice dishes either alone or flavored with soup stock, minced beef, chicken, tongue or ham, chicken livers, mushrooms, cheese, tomatoes, onion, peppers, celery, olives, etc. in various combinations.
Casserole dishes—Small meat pies and all kinds of combinations of meat with potatoes (also rice or bread crumbs) and other vegetables.
Stews and **ragouts** of meat with vegetables, curried lamb and rice, chop suey, meat loaf, hash, etc.
Meat substitutes—Legume and nut dishes (also egg and cheese dishes as above), *e. g.*, either peanut butter, other chopped or ground nuts, bean or pea pulp mixed with cracker or bread crumbs, milk, egg, and seasonings, molded into loaf and baked.
Creamed dishes—minced chicken, fish, dried beef, hard-boiled eggs, sweetbreads, mushrooms or vegetables with cream sauce—either alone or on toast.
Toasts—Milk or cream toast, cheese toast, minced meat with thin gravy on toast, creamed vegetables on toast (*e. g.*, creamed celery, asparagus, onion, spinach, etc.), lima beans or baked tomato on toast.

Salads

Chicken, fish, egg, cream cheese and nut salads.
Any salad of green stuffs, other vegetables or fruits.

Ways of Using Milk

As a beverage—plain (cold), with coffee or coffee substitute (hot), in cocoa or chocolate, as buttermilk or malted milk, with egg, cocoa or bland fruit pulp added.
On foods—on cereals or desserts (top milk).
In cereal foods—to moisten doughs (as in milk bread or biscuits), breakfast cereals cooked in milk, in escalloped dishes, croquettes, etc.
In sauces—in cream sauce for vegetables, and thin custard sauce for desserts.
In soups—cream soups (for varieties see p. 389), chowder, oyster stew, etc.
In desserts—puddings, custards, ice creams, etc. (see list of desserts, p. 391).

Variety in Dinner. While this is a more stereotyped meal than luncheon or supper, there is plenty of chance for variety in the dinner menu. If the meal is simple, there may be a choice in the courses served—*e. g.*, meat course, salad, dessert; soup, meat course, dessert; soup, meat course, salad. The more elaborate the meal, the harder it is to secure variety from day to

DESSERTS

Light.	Medium.	Heavy.
Fruits Fruit whips or snows Fruit jellies (gelatin) Junket Simple custards—boiled or baked Simple puddings of tapioca, sago or rice combined with fruits Simple frozen desserts Frappés Ices Sherbets	Simple cake or cookies Shortcakes with fruit filling Tarts with fruit filling Soufflés Cream puffs Cornstarch puddings, *e. g.*, blanc manges, etc. Baked puddings, *e. g.*, bread puddings, cottage puddings, cabinet puddings, Indian puddings, custard rice puddings Milk and gelatin combinations, *e. g.*, Spanish creams Waffles, pancakes or French toast with jelly or jam	Cheese desserts Chocolate desserts Shortcakes with whipped cream Pies, esp. with cream filling Washington pie Cakes—rich ones and those with much frosting Doughnuts Steamed puddings, esp. those with suet, dates or figs, nuts, rich sauces, whipped cream Bavarian creams Macaroon puddings Frozen desserts Ice creams Mousses Parfaits Frozen puddings Nuts, dates, figs, raisins and candy

day. In the more formal type of dinner, the use of certain foods in a fixed order is decreed by convention, but even here there is room for variety in most of the courses. The RELISHES or hors d'oeuvres which may be used are numerous; while clear SOUPS are preferred, thin cream soups may also be served for dinner. There is a choice between MEAT, FISH or POULTRY, between DIFFERENT CUTS of the same meat, and in the MANNER OF COOKING the meat (see p. 393); an enormous number of different combinations of meats with various VEGETABLES is possible. SALADS may be varied almost indefinitely. There is not such a wide choice of DESSERTS, if one sticks to the lighter desserts that are the more suitable ones to use in a hearty meal like dinner, and the post-dessert course is limited by convention to a few foods such as crackers and cheese, candies, nuts or dried fruits served with the coffee.

Soups—MEAT SOUPS—bouillon, consommé, beef broth, mutton broth, chicken, oxtail, hare, turtle, mock turtle and mock chicken.

—VEGETABLE SOUPS—tomato and celery, tomato bouillon, mixed vegetable soup, vegetable bouillon, celery, asparagus, artichoke, onion, okra, knob celery, and vegetable oyster.

—CREAM SOUPS—see list on p. 389. Thick purées, chowders, etc. are not suitable for dinner.

Vegetables STARCHY—potatoes, sweet potatoes, corn, peas and beans; also rice, macaroni, etc.

—LEAFY—spinach, dandelion greens, beet tops, turnip tops, Swiss chard, kale, cabbage, Brussels sprouts, lettuce, romaine, endive, escarole, Chinese cabbage, etc.

—ROOT—beet, carrot, turnip, parsnip, vegetable oyster, kohlrabi, knob celery.

—SUCCULENT—celery, radishes, green onions, asparagus, broccoli, cauliflower, artichokes, palm cabbage, tomatoes, cucumbers, eggplant, squash, vegetable marrow, string beans, okra, green peppers.

Salads Heavy salads are not suitable for dinner. In general those made with French dressing are preferable to those with mayonnaise dressing.

Desserts—See the list of desserts given above (p. 391).

The simple desserts (first column) are those best suited to dinner, fresh fruit being the very best dinner dessert.

If the dinner menu is not elaborate, small servings of the richer desserts may be used.

Meat (*i. e.*, meat, poultry or fish) usually forms the PIÈCE DE RÉSISTANCE of dinner for most people. Because many persons seem to have difficulty when planning meals in remembering the different kinds of meat available, some of the possible variations of the meat course are suggested in the table on p. 393.

When the use of meats must be limited either because of scarcity or high cost, the **meat substitutes** (dishes using eggs, cheese, milk, legumes and nuts, as suggested under luncheon menus, p. 390) are available, and it is a good thing to use such dishes in place of meat at dinner occasionally in any event.

Utilization of Left-over Foods. Economy of Labor in Preparing Meals. Important as these two considerations are, we may treat both of them together in a few paragraphs—first, because they are so closely related, and second because the general principles with regard to them are well known, though not equally well observed. Using up **left-overs** is no disgrace; in fact one should deliberately PLAN to carry over some foods from day to day in order to market more economically, and to save labor and fuel in cooking. In addition, the use of material which would otherwise be wasted is much to be encouraged, especially among Americans, who are inclined to be a wasteful people. Things usually thrown away, which should be USED IN SOUP, are water in which vegetables have been cooked and the liquid from canned vegetables, celery tops, outside leaves of lettuce, cabbage and cauliflower, meat and chicken bones. Using the tops of such vegetables as beets and turnips will provide two vegetables for the price of one, and one of them a leafy vegetable valuable for vitamins

TABLE XXIV. MEATS AND WAYS OF COOKING THEM

Beef.	Veal.	Mutton or lamb.	Pork.
Steaks: Broiled, Pan-broiled, Braised, With sauce	Cutlets: Plain, Breaded, With sauce	Chops: Plain, Breaded, With sauce	Chops: Plain, Breaded, With sauce
Roasts: Oven roasts, Pot roasts	Roasts	Cutlets	Roasts
Cheaper cuts: Stews, Meat pies, Ragouts	Stews, meat pies, etc.	Roasts	Ham: Broiled, Boiled, Baked
Ground beef in loaf or patties		Boiled (leg of mutton)	Sausages
Corned beef		Braised (" " ")	Salt pork
		Stews, etc.	Bacon
			Pigs feet—pickled

Organ meats.	Poultry.	Game.
Tongue: Boiled, Pickled	Chicken: Boiled (fowl), Broiled, Fricassée, Fried, À la Maryland, à la King, Pie, Roasted	Venison: Roasted, Broiled, Ragout
Heart—Stuffed	Capon—roasted	Rabbit: Roasted, Fricassée, Pie
Sweetbreads: Broiled, Creamed, Ragout	Turkey—roasted	Game birds—roasted
Liver: Fried, Purée, Ragout	Duck—roasted	Partridge
Kidneys: Stewed, Broiled	Goose—roasted	Pheasant
Brains: Fried, Head cheese	Guinea-hen: roasted, ragout	Grouse
Tripe: Fried, Creamed		Quails
		Snipe

Fish.

Boiled.*	Baked.	Broiled.	Fried.
Halibut	Bluefish	Bass	Carp
Kingfish	Carp	Bluefish	Flounders
Pike	Pike	Halibut	Halibut
Trout	Trout	Kingfish	Smelts
Salmon trout	Salmon trout	Mackerel	Sole
Sea trout	Sea trout	Shad	Swordfish
Sea bass	Sea bass	Smelts	All small fish
Shad	Shad	Sole (Flounders)	
Spanish mackerel	Spanish mackerel	Spanish mackerel	
Striped bass	Striped bass	Trout	
Weakfish	Weakfish		
Whitefish	Whitefish		

* Have in the water 2 onions, 1 large carrot, knob celery or celery leaves, parsley or 1 to 2 cloves of garlic, and let fish simmer in this broth till done.

and minerals. Chopped carrot tops and parsley may be sprinkled on soup. Serving some vegetables raw (carrots, turnips, cauliflower flowerets, etc.) is good nutritional practice and saves on fuel.

Left-over meats, potatoes and other vegetables may contain a good deal of nourishment and, if they have not been served out on the plates, there can be no objection to using them. The second appearance of a food may be just as appetizing and often quite different from the first form of serving

it. Warmed-up POTATOES and left-over MEAT DISHES are familiar to all. Left-over VEGETABLES may be served in cream sauce, in soups, or in salads. FRUITS may do double duty in salads and in flavoring desserts. Odds and ends of BREAD and left-over CEREALS can be used in puddings, croquettes, stuffed vegetables, escalloped or casserole dishes, etc.

One should remember that the use of left-overs is entirely **consistent with cleanliness** when they are REHEATED before serving a second time, but PROTEIN FOODS, which are subject to spoilage, should not be kept long and **all left-over foods should be kept well refrigerated in covered dishes.** There is no basis for the idea that CANNED GOODS must be thrown out if not used at once; most people prefer to keep them in a glass jar or earthenware dish rather than in the tin, though there is no proof of danger from the tin can; they should be kept cold, protected from the air, and usually should be reheated before serving. Foods which show any EVIDENCES OF SPOILAGE (bad odor, gas bubbles, peculiar flavor, etc.) should never be used.

Although left-over foods should not be wasted and the cooking of an extra quantity of food at one time saves time and fuel, an exception should be made as to the **vitamin-bearing fruits and vegetables.** In so far as is practicable, these foods should be prepared immediately before serving and in the quantity likely to be used at one meal, since there may be considerable loss of vitamins on standing (especially exposed to air) and in reheating.

The chief device for saving **labor** and **fuel** in preparing meals is to use the same METHOD of cooking for most of the foods in the same meal—*i. e.*, when planning an oven-cooked meat, have several other foods in the meal which can be cooked in the oven along with the meat; when using a meat which is quickly cooked, have vegetables and dessert such that they can also be quickly cooked or prepared beforehand. Considerable economy of time and fuel may be effected by careful meal planning. The labor of preparing meals may be still further reduced by serving FEWER FOODS at a meal and by using some foods in the RAW state, both of which are practices to be encouraged in the interests of physical welfare. At least one raw food should be used daily. The less elaborately prepared foods are better for digestion and save work.

Planning Menus for a Week. In the week's menus given at the close of this chapter, the chief aim has been to illustrate the NUMEROUS WAYS IN

WHICH VARIETY MAY BE INTRODUCED. Most persons would be satisfied with a good deal less variety in their meals, with a resultant ECONOMY in cost and in labor of preparation. The use of left-overs and economy of time and fuel have also been kept in mind, however, as will be apparent on looking closely at the menus on p. 396. The reader is asked to observe especially—

(1) The wide variety—in types of menu used
—in foods used
—in ways the same food is served

(2) Use of left-over meats—Sunday chicken in chicken pie Monday and chicken soup Tuesday
—Wednesday beef in meat loaf Thursday and chop suey Friday
—Friday fish in fish chowder Saturday

(3) Other foods carried over—outer parts and tops of celery in creamed celery on toast, cream celery soup and American chop suey
—liquid from canned asparagus in cream asparagus soup
—juice and left-overs from canned pineapple in pineapple sherbet
—apricots used again in apricot whip
—left-overs of fruits in fruit salad
—left-overs of vegetables in vegetable salad, creamed carrots, and warmed over potatoes
—extra rice cooked for use in rice pudding next day

(4) Meals chiefly cooked in oven—Sunday dinner
Monday dinner
Thursday lunch
Thursday dinner

Quickly prepared meals (excepting breakfasts)—
Sunday supper
Tuesday dinner
Friday dinner
Most of the lunches, if desserts are prepared beforehand.

(5) Balancing foods within the meal—use of ONE main protein dish to a meal
—use of light salad or dessert with heavy meal, and vice versa
—use of highly flavored foods with bland foods
—use of hard or crisp foods with soft foods

(6) Balancing meals in a day—getting in suitable amounts of the essential foods each day (milk, eggs, fruits, vegetables)
—not repeating same food in one day
—making luncheon heavier when dinner is lighter, and vice versa

(7) Bread and butter, and also beverages (exc. coffee at breakfast), are omitted from the menus on the assumption that they will be used as desired.

MENUS FOR A WEEK*

	Sunday.	Monday.	Tuesday.
Breakfast	Baked apples Scrambled eggs and bacon Toast Coffee	Oranges Oatmeal Muffins Coffee	Grapefruit Shirred eggs garnished with small sausages Toast Coffee
Luncheon	(Dinner) Ox-tail soup Baked sweet potato Roast chicken Celery hearts Creamed onions Asparagus tip salad Caramel blanc mange with whipped cream Sweet wafers	Tomato omelette Creamed potatoes Green peas Lettuce salad Apricot whip Cookies	Chicken soup Creamed celery on toast Pineapple and cream cheese salad Macaroon pudding
Dinner	(Supper) Peanut butter, lettuce and fresh tomato sandwiches Cocoa Stewed apricots Cake	Cream asparagus soup Baked potatoes Chicken pie Brussels sprouts Pear salad Cabinet pudding with lemon or chocolate sauce	Hashed brown potatoes Lamb chops Beets Kohlrabi Lettuce salad Ice cream Cake

	Wednesday.	Thursday.	Friday.	Saturday.
Breakfast	Stewed figs Graham mush Toast Coffee	Apples (raw) Corn flakes Liver and bacon Muffins Coffee	Bananas Wheatena Toast Coffee	Oranges Boiled eggs Griddle cakes and syrup Coffee
Luncheon	Baked eggs with cream sauce Cauliflower au gratin Lettuce salad Spanish cream	Casserole of macaroni, cheese and green peppers Creamed carrots Baked custard Cookies	Boiled rice American chop suey String beans Raspberry jelly with whipped cream Cookies	Fish chowder Waldorf salad } apple, celery and nuts Plain rice pudding with raisins
Dinner	Bouillon Pot roast of beef with brown gravy Boiled potatoes Carrots Mixed vegetable salad Sliced oranges, garnished with cocoanut Cookies	Meat loaf with tomato sauce Scalloped potatoes Swiss chard Lettuce salad with Russian dressing Lemon meringue pie	Cream of celery soup Broiled mackerel Mashed potatoes Succotash Romaine salad with Roquefort dressing Apple sauce Cake	Consommé Boiled ham Delmonico potatoes Creamed spinach Lettuce salad Pineapple sherbet Sweet wafers

* These menus, and those in the preceding chapter, were planned chiefly to illustrate certain principles of meal planning, assuming normal food supplies and costs. In periods of abnormally high cost of foods (such as the present time, 1948), numerous economies might be made, particularly the use of less meat, more meat extender dishes and meat substitutes, less free use of eggs, and use of fortified margarine, instead of butter. However, since this textbook is planned for long-term use and there is hope for restoration of normal food economy before too long a period, it seems best to retain the menus as they stand. They set a standard, nutritionally and gastronomically, to which we hope to return and which can be adapted to current conditions by substituting less expensive foods of the same class or type for those that happen to be most costly at the moment. More detailed suggestions as to economy in meal planning will be found in the following chapter.

QUESTIONS AND PROBLEMS

1. Give practical ways of introducing variety into the breakfast menu, the dinner menu, and the lunch or supper menu.

2. Why is it impractical to provide variety by serving many different

foods in one meal or day? Why is a wide variety of foods used from day to day, or week to week, good nutritional practice? How can sufficient variety be made consistent with the use of left-over foods? What would you say is the "golden mean" as to variety in meals?

4. Explain why it is advantageous to plan meals and market lists for the week, and to shop for foods only two or three times a week, if possible.

5. Plan a week's menus for a young couple at moderate cost level. Check these menus to see whether they provide the classes of foods, and sufficient amounts of each food group, to be adequate for energy, high quality protein, mineral elements, and vitamins. If time permits, different sets of menus may be checked quantitatively by calculating from food tables how much of any of these nutritive essentials is provided.

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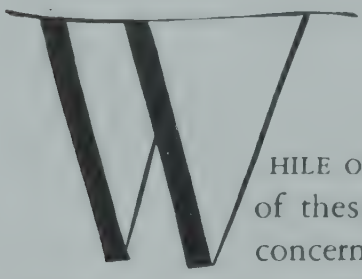
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These two bulletins are available free from the Office of Information, U. S. Department of Agriculture, Washington 25, D. C.

CHAPTER 23

FOOD ECONOMICS AND INFLUENCES OF COOKING



HILE only a brief résumé of the more important aspects of these problems can be included in a book primarily concerned with nutrition, it seems essential to mention them and to point out the intimate relation of these subjects to the nutritional welfare of the individual and the family. It is obviously of vital **concern to persons of small incomes** to know how to meet their nutritional needs at as low a cost as possible. Without such knowledge they are very likely either to spend too large a proportion of their income for food or to have a diet which will not supply the nutritive material necessary to build strong bodies. It requires careful selecting of foods, economical buying and control of waste in the home in order to secure an adequate diet on a limited amount of money.

Moreover, in this relatively prosperous and extravagant country of ours, **many families spend more for food than they need to,** and often more than they are justified in spending, if the other needs of the family are to receive due consideration. High cost does not always mean the BEST food in the physiological sense, as is evidenced by the great amount of indigestion, overweight or malnutrition among wealthy people who live luxuriously at home, go the round of social functions, and eat at expensive hotels when traveling. SIMPLER AND LESS EXPENSIVE FOODS are often MORE WHOLESOME, but there is a **lower limit** below which one cannot reduce food costs and provide adequately for body needs.

To what extent and by what means may food costs be reduced without sacrificing either the palatability or nutritive efficiency of the diet? What represents the "golden mean" between extravagance and penury as to food expenditures? How may an adequate diet be secured at the lowest possible cost when necessary? These are the questions which we shall attempt to meet in this chapter.

FOOD ECONOMICS

How Much Should Be Spent for Food at Different Income Levels. While this is to some extent an individual problem, usually the less the

income, the greater the proportion of it which will need to go for food in order to secure a nutritionally adequate and satisfying diet. The higher the cost of foods or the lower the purchasing power of the dollar, the more difficult it becomes to secure an adequate diet with much variety or "frills" for the proportion of the income that should go for food. For instance, a family of four which has a total income of $2000 to $3000 per year formerly could purchase, with careful selection and marketing, what the U. S. Bureau of Home Economics classifies as a MODERATE COST ADEQUATE DIET by spending $\frac{1}{4}$ to $\frac{1}{3}$ of their income for food. At 1947 prices the same amount of money would buy only a MINIMUM COST ADEQUATE DIET and a low income family ($1000–$1500 per year) would have to spend $\frac{2}{3}$ of their total funds for food in order to have a diet of this standard. Surveys have shown that low income families[1] do spend 45–60 per cent of their funds for food, with the result that money for rent, fuel and clothing is much too limited for family welfare. On the other hand, a family of four with an income of $5000 to $6000 per year at present prices could purchase a MODERATE COST ADEQUATE DIET for about $\frac{1}{5}$, or a LIBERAL DIET for $\frac{1}{4}$, of their income. The dietary standards of the American people have not been so much affected by the post-war price inflation as might be expected, since the level of wages and income has usually increased along with prices. Where this is not true and for families below a certain income level, real hardship may result or cash assistance be needed to avert malnutrition, especially when there are young children in the family. Even at moderate income levels in times of high food costs, it takes careful planning to get enough energy foods, plenty of high quality protein and the amount of "protective" (mineral and vitamin-bearing) foods that will be adequate to insure good health over a long period.

It is easy, however, to spend more for food than is necessary from a nutritional standpoint or than is advisable if one considers the welfare of the family as a whole. **The larger the amount spent for food, the less money is left for the other needs of the family.** While a small family with a liberal income does not need to worry about such considerations, the moderate-sized or large family with income between $3000 and $6000 will often be better-advised to follow a moderate-cost plan in food choices.

[1] A study of income distribution in 1945 made by the Federal Reserve Board and the Bureau of Agricultural Economics showed that, of the 45,000,000 families studied, 47 per cent had annual incomes of $2000 or less, while nearly one half of these received less than $1000 per year. By mid-fall of 1946, these agencies estimated that an income of $4,719 was necessary for a family of four to maintain the same standard of living made possible by an income of $3,200 in 1941. In the face of sharply rising prices, it is evident that great care is needed in planning expenditures by approximately half of American families.

instead of the liberal-cost level of food expenditures. People can make a habit of eating so heavily and of enjoying the more expensive foods to such an extent that money goes for food which would better be spent for recreation, housing, etc., or saved for educating the children or for emergencies.

The small family (especially if limited to adults) always has more leeway as to the amount to be spent for food than larger families with several young children who need a larger allowance of certain relatively more ex-

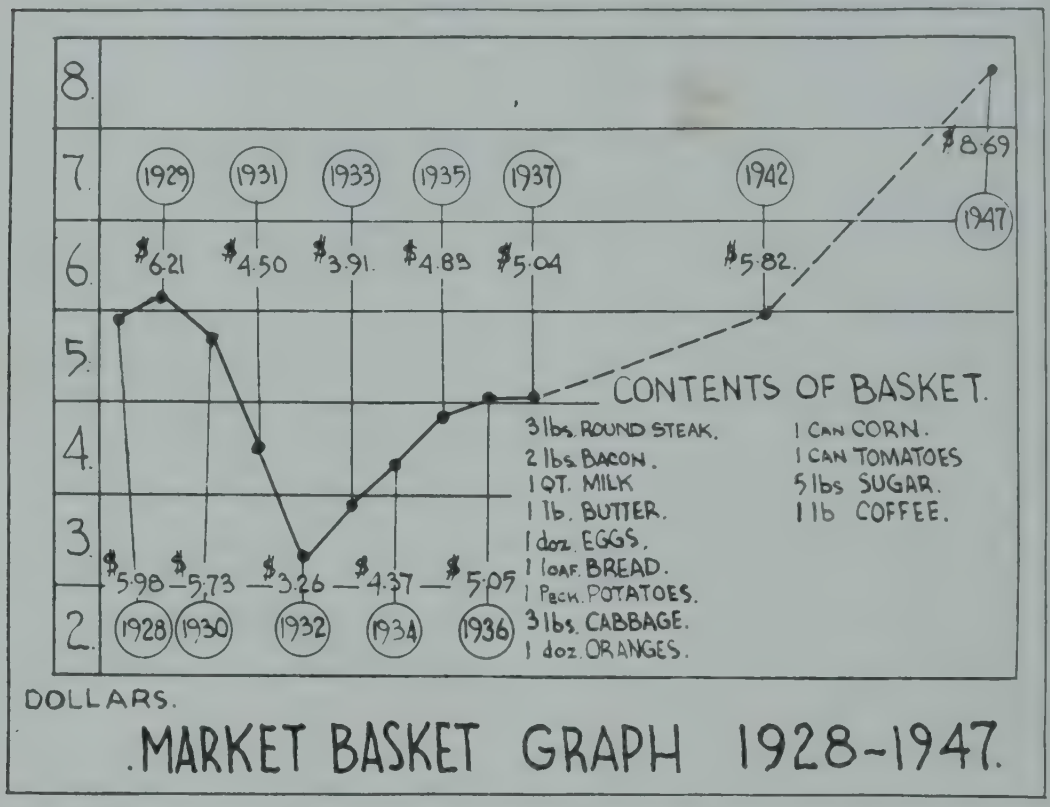


Fig. 73. Fluctuations in purchasing power of the dollar, as shown by relative costs of the items, listed as contents of the basket, in different years. It cost 72 per cent more to purchase these items in July, 1947 than in July, 1937 (based on average U. S. prices as reported by the Bureau of Labor Statistics).

pensive foods (milk, eggs, fruit and vegetables). Other factors besides SIZE OF THE FAMILY should be taken into consideration, such as whether one resides in a relatively more or less expensive SECTION OF THE COUNTRY, in a CITY or on a FARM, and general economic conditions.

The wide **fluctuations in the purchasing power of the dollar** over a period of years are shown graphically in Figure 73. It will be seen that the same foods that could be bought for $3.26 in the autumn of 1932 (the low point of the curve) would cost over $8 in July of 1947, according to average retail prices in over 50 cities reported by the U. S. Bureau of Labor

Statistics. It should be noted that the "market basket" contains larger quantities of relatively costly foods (meat, bacon, eggs, butter), so that it is not a true picture of what it costs to get an adequate diet. Taking average food costs in the period 1935–39 as 100, the same government bureau estimates the average price index for all foods in July, 1947 as 193, which means food costs have nearly doubled or we now have a "50 cent dollar." However, food prices were nearly, if not quite, as high following World War I (in 1919) and the fact remains that the present high food prices are due to general inflation rather than to scarcity of food. In spite of high prices, the American people are eating more food than before World War II.

Because it is impossible to tell how much foods will cost at any given time, discussion of food costs should always be on a **relative** basis. Certain KINDS of food are relatively high-priced and others are relatively low-cost at any date. Moreover, it is essential to take into account what return in nutritive value is obtained for equal amounts of money when spent for different types of food.

What the Different Food Groups Contribute to Diet. It is impossible to direct expenditure for food wisely unless one realizes what we buy different foods or food groups for. Certain classes of food are especially **economical** for meeting our requirements **for energy.** For fuel values purchasable for one cent see chart in Figure 74. Other foods we buy chiefly for their contribution of good quality **proteins** in the diet; still others, though expensive from the standpoint of the energy or protein which they furnish, **yield good return** in the essential **mineral elements** and **vitamins** which they contain. As a preface to considering which classes of foods we would depend upon most heavily at different cost-levels, it seems advisable to summarize what the different food groups contribute:

Grain products—Cheap sources of fuel and protein; whole grains are inexpensive sources of minerals and vitamins, especially iron and vitamin B_1; highly milled cereal products, unless artificially enriched, are deficient in most mineral elements and vitamins.

Sugar and fats—Cheap or moderate-priced sources of fuel; completely lacking in protein, mineral salts and fiber; deficient in vitamins, except that butter and fortified margarine are valuable sources of vitamin A while other animals fats furnish smaller amounts of this vitamin.

Meats—Relatively expensive sources of protein and fuel; deficient in some mineral salts and vitamins but good sources of iron and B-complex vitamins.

Eggs—Relatively expensive sources of protein and fuel; but rich in mineral elements and vitamins.

Milk and cheese—Moderate-priced sources of protein and vitamin A but least expensive sources of calcium and riboflavin (vitamin B_2).

Fruits and vegetables—Usually expensive sources of protein and fuel, but especially important to furnish fiber, mineral elements and vitamins, especially vitamin C.

Hence, it should be apparent that, although we could get a very **inexpensive supply of fuel** from GRAIN PRODUCTS, SUGAR and the cheaper FATS, these food groups alone would not furnish all of the nutritive elements essential to health. At least a certain amount of DAIRY PRODUCTS, MEAT and EGGS, FRUITS and VEGETABLES will be necessary to provide high quality protein, mineral elements and vitamins. The relative prominence of these more expensive food groups in the diet will be largely determined by the amount of money which can be spent for food.

There are three ways to keep food costs down, namely (1) by choosing foods CHIEFLY FROM THE CLASSES OF FOOD THAT ARE RELATIVELY CHEAP and using the higher cost food groups as sparingly as is compatible with health; (2) by having all food groups well represented in the diet but USING THE LESS EXPENSIVE FOODS IN EACH GROUP; (3) by buying shrewdly and ELIMINATING ALL WASTE; also by conserving the nutritive value of foods in cooking.

In low-income families, all three types of economy must usually be practiced if an adequate diet is to be provided. Those who have somewhat more money to spend for food will be better fed by following the second means of economizing, while persons at any income level will profit by the third plan, which insures getting full value for money spent.

Reducing Food Costs by Using More of the Less Expensive Food Groups. In low-cost dietaries, one of the main problems is to get enough body fuel for the money available, and hence a relatively LARGER PROPORTION of the food supply comes from the types of food that are INEXPENSIVE SOURCES OF ENERGY. From the chart on p. 403 it can readily be seen that the most calories can be bought for a given sum in the form of bread and other cereal foods, potatoes, and other starchy vegetables, sugar and the cheaper fats. As much as two thirds of the calories may be furnished by such low-cost foods, and the less money available for food the more prominent they will have to be in the diet.

Cereal products and starchy vegetables may be used more safely in large quantities than sugar and fats, as the latter foods (when consumed in excessive amounts) tend to sate appetite, disturb digestion, and provide a diet that is too low in vitamins, minerals and protein. When cereal products bulk large in the diet, it is important that whole grain or enriched products be used, since these carry a valuable quota of minerals and vitamins (as do also potatoes). Government surveys made in 1942 showed that, although grain products accounted for only 11 per cent of the costs, they contributed 30 per cent of the calories in the average American diet, along with 28 per cent of the protein, 21 per cent of the iron and 22 per

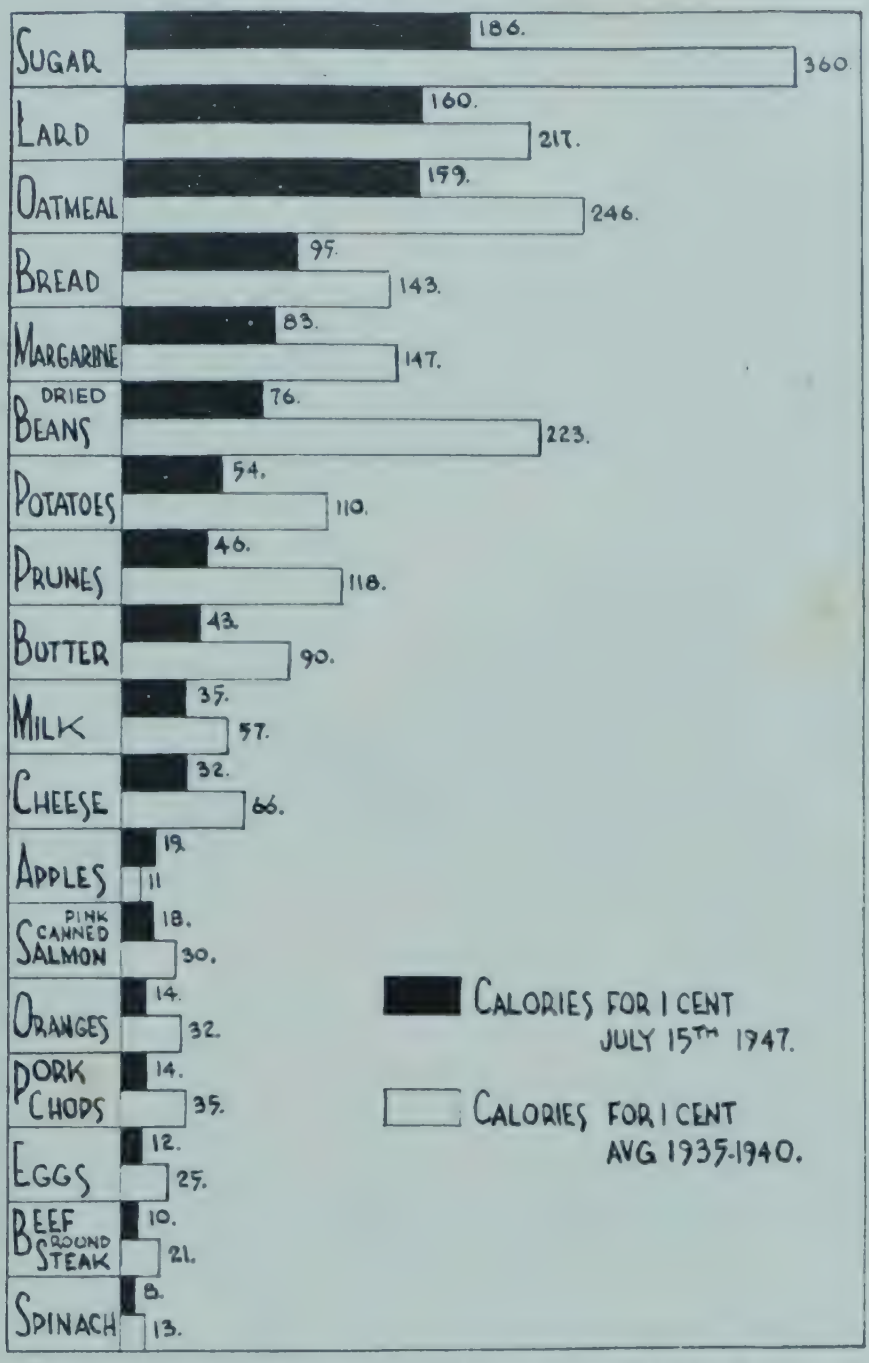


Fig. 74. Relative economy of different foods as sources of body fuel, average 1935–1940 prices compared with those of July, 1947 (based on retail prices in over fifty cities, U. S. Bureau of Labor Statistics).

cent of the thiamine (vitamin B_1). Sherman believes that grain products alone may safely furnish as high as 40 per cent of the total food energy.

But even a low-cost diet should provide adequate protein, minerals and vitamins, as well as energy. The charts in Figures 75 and 76 (pp. 404–405)

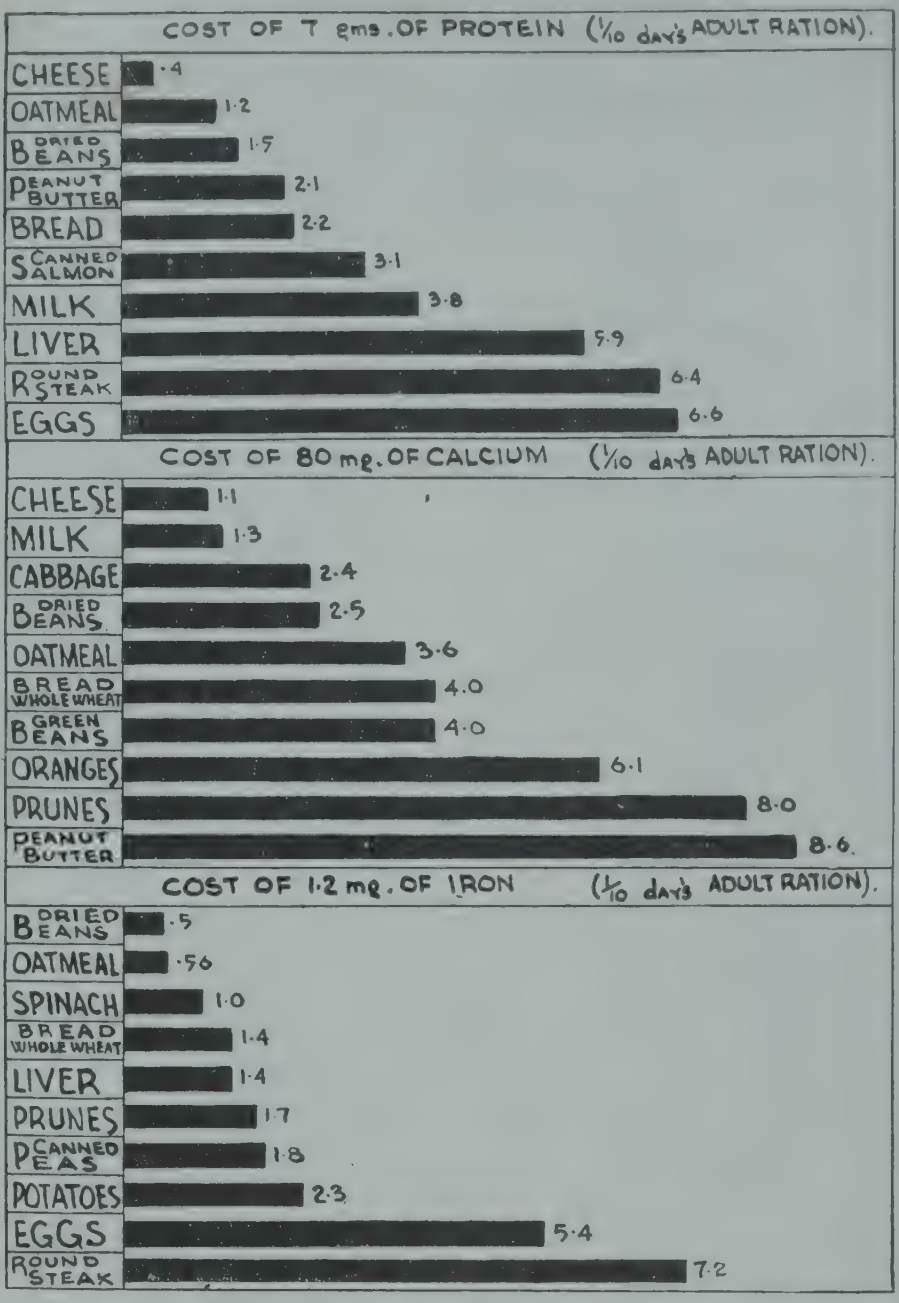


Fig. 75. Relative costs of 1/10 of the daily adult allowance of protein, calcium, and iron, as purchased in various typical foods (based on U. S. Bureau of Labor Statistics average prices, July 15, 1947).

show the relative costs of $\frac{1}{10}$ of the daily adult allowance for protein, calcium, iron, and vitamins A, B_1, and C, as purchased in various typical foods. Even at 1947 prices (when meat, eggs and butter are unduly high), it will be seen that by far the CHEAPEST SOURCES of these essential nutrients are:

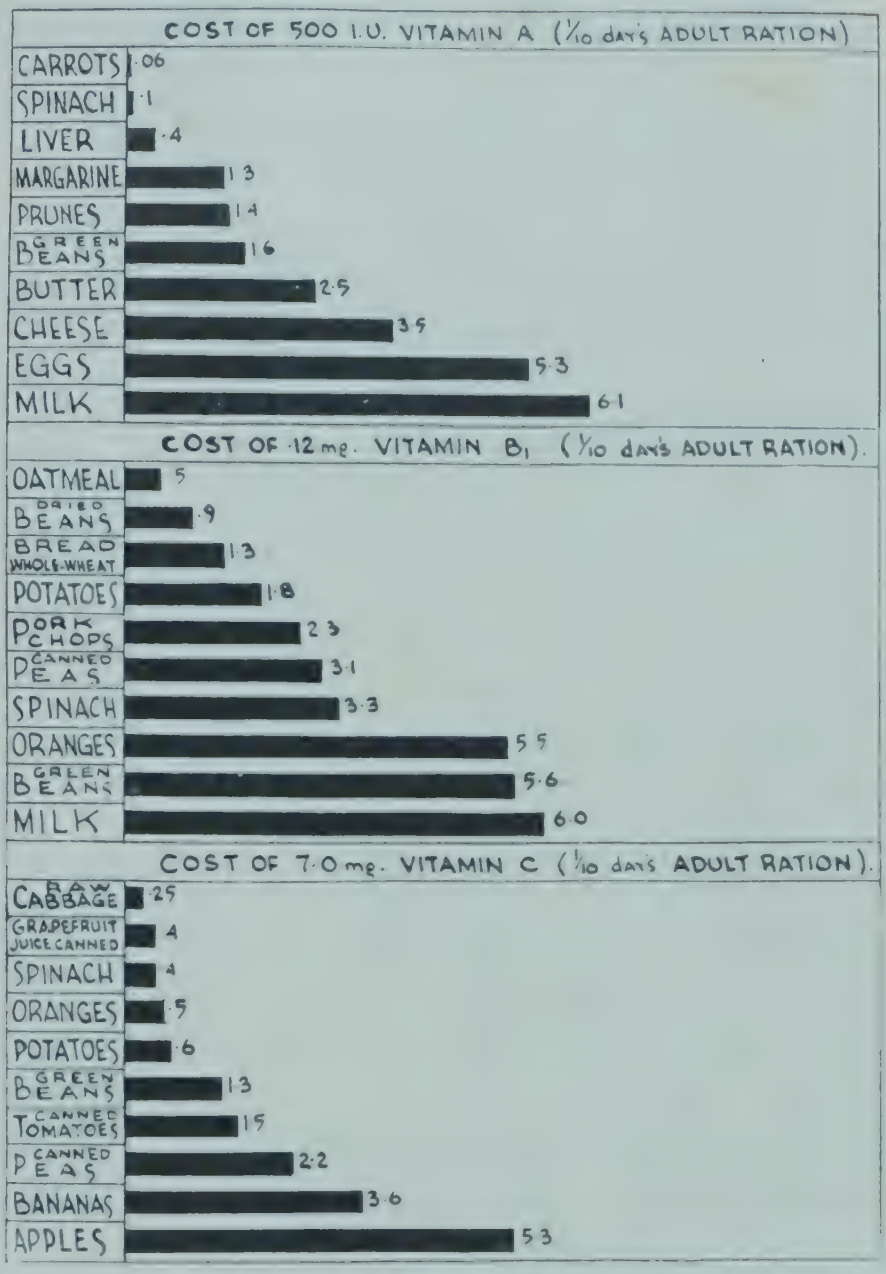


Fig. 76. Relative costs of 1/10 of the daily adult allowance of vitamins A, B_1, and C, as purchased in various typical foods (based on U. S. Bureau of Labor Statistics average prices, July 15, 1947).

For PROTEIN — (vegetable) grain products, legumes (especially dried), peanut butter, (animal) cheese, milk, and cheaper kinds of fish or meat

For CALCIUM — cheese, milk, leafy vegetables (except beet tops, chard and spinach), legumes, and whole grain products.

For IRON — legumes (dried or canned), whole grain products, leafy vegetables, liver, and prunes.

For VITAMIN A leafy vegetables, yellow vegetables, liver, margarine, green beans, and prunes.

For VITAMIN B_1 whole grain products, dried legumes, potatoes, pork, canned peas.

For VITAMIN C—raw cabbage, canned grapefruit juice, oranges, leafy vegetables, potatoes, and canned tomatoes.

From the above summary, it will be apparent why the free use of whole grain bread and cereals, potatoes, leafy and yellow vegetables, legumes, cheese and milk, is recommended for the low-cost diet. Evaporated or dried whole milk are cheaper than fresh whole milk and have the same food value; even dried skim milk is useful in cooking to add calcium and B-complex vitamins. Since meat is usually the most expensive item of the diet, low-income families are advised to serve cheaper cuts (such as chuck, breast of veal, shoulder of lamb, chopped meat, and stew meat) only three or four times a week, and to use fish, legumes, and an egg or cheese dish on the other three or four days. Thus by sacrificing variety and using chiefly the foods that provide good quality protein, minerals, and vitamins at relatively low cost, these nutritive essentials need not be lacking in the diets of low-income families.

Obviously **as more money is available for food,** carbohydrate-rich foods and the less expensive fats need not be so extensively used, and the **amount spent for eggs and meat, table fats, cream and milk, fresh fruits and vegetables can be increased.** From a health standpoint, a larger expenditure for such foods in higher-cost dietaries is well justified since they are valuable for VITAMINS and MINERALS, an EXCESS supply of which above minimum requirement is known to make for INCREASED VITALITY and RESISTANCE TO DISEASE.

Substitution of Cheaper for More Expensive Foods within the Same Food Groups. This is another way to reduce food costs and is the BEST PROGRAM TO FOLLOW WHERE ONLY MODERATE REDUCTION OF FOOD EXPENSE IS REQUIRED, because none of the nutritive advantages of the higher cost diet are sacrificed, *e. g.*, one can have the advantages of using fruits and vegetables LIBERALLY but keep down cost by selecting only the least expensive KINDS of fruits and vegetables. In a moderate cost diet, the relative AMOUNTS of milk, fats, flesh foods and eggs can remain practically the same as in the high-cost diet. Considerable reductions in costs may be made, however, by using cheaper substitutes for the more expensive foods within the same group. How this kind of food economy may be effected is outlined below:

Grain products—Even in this relatively inexpensive food group some foods are cheaper than others.

CORN and RICE are usually cheaper than wheat.

The lighter, READY-TO-SERVE CEREALS are relatively EXPENSIVE.

UNCOOKED CEREALS bought IN BULK are cheaper than packaged goods.

OATMEAL and WHOLE WHEAT CEREALS give especially good value because of their higher content of protein, mineral salts and B-complex vitamins.

Home-made BREADSTUFFS are cheaper than bakery products, and plain breads are cheaper than those with special flavor appeal. Crackers, sweet buns, cake, cookies and doughnuts are expensive when purchased at the store.

Half of the bread and cereals should be whole grain or enriched.

Sweets—SUGAR is one of the cheapest fuel foods but should not furnish more than 10 per cent of the total calories.

GRANULATED white sugar and BROWN sugar are cheapest; POWDERED sugar, LOAF sugar and MAPLE sugar are considerably more EXPENSIVE.

MOLASSES, CORN SIRUP and CANE SIRUPS are inexpensive; blended sirups are moderate-cost; maple sirup and strained honey are expensive. Molasses and open kettle sugar cane sirup have a MINERAL CONTENT valuable in a low-cost diet (see table, p. 23).

JELLIES, JAMS, marmalades and preserves are usually relatively expensive, but may be useful to render bread and other inexpensive starchy foods more acceptable. Home-made jams and jellies are least expensive.

CANDY, except for simple hard candies, is an expensive form of sweets.

Fats—MEAT FATS, LARD and LARD SUBSTITUTES, and SOME VEGETABLE OILS (cottonseed and corn oils) are the least expensive fats; MARGARINES are moderate-priced; BUTTER and OLIVE OIL are the most expensive fats. MARGARINE FORTIFIED WITH VITAMIN A has about the same food value as butter.

Protein-rich foods—The CEREAL GRAINS and LEGUMES are the cheapest sources of protein but should not be the only protein-bearing foods in the diet, because most of the vegetable proteins are incomplete proteins; American (cheddar) CHEESE provides excellent quality protein at low cost and MILK at moderate cost; when EGGS are moderately priced, they are a more economical source of protein than most cuts of meat, but at 1947 prices eggs rank with round steak for protein value, and the cheaper cuts of meat may be a better buy; NUTS and most FLESH FOODS (meats, fish and poultry) are usually the most expensive of the protein-rich foods.

Flesh foods—Within this group there are very great differences in cost levels. Certain FATTY MEATS may be relatively inexpensive; next come the CHEAPER CUTS of red meats and the less expensive FISH; next the more TENDER CUTS of lean meats and cuts that involve considerable waste, along with the more expensive forms of sea food; POULTRY is usually more expensive because of the waste involved. DRIED OR CANNED FISH may offer good protein at lost cost; canned pink SALMON is valuable for vitamins A and D, and costs less than red salmon; FROZEN FISH are of excellent quality and have little waste.

Fruits—DRIED FRUITS (raisins, dates, figs, apricots, prunes, peaches and apples) are sometimes the most economical of the fruits. Any of them that are relatively inexpensive (*e. g.*, prunes) should be used in the low-cost dietary.

CANNED FRUITS are often less expensive than fresh but may not be.

Of the FRESH fruits, APPLES, BANANAS and ORANGES are apt to be the least expensive, though some of the others may be relatively cheap at the height of their season. The CITRUS FRUITS and TOMATOES are especially valuable for their vitamin C content.

Most expensive are the less common fruits and fresh fruits which are out of season.

Vegetables– POTATOES and the ROOT VEGETABLES are usually the least expensive.

CABBAGE and some of the other LEAFY VEGETABLES in their season are relatively inexpensive.

GREEN and YELLOW VEGETABLES have the highest vitamin A value.

DRIED LEGUMES are usually cheap; canned vegetables are often moderately-priced, and CANNED TOMATOES are especially useful to add flavor and vitamins in a low-cost diet.

FROZEN vegetables (and fruits) are relatively expensive, but afford variety in liberal cost diets. They are without waste and with full nutritive value of fresh ones.

Most FRESH vegetables (especially the succulent ones) are at least fairly expensive except at the height of their season.

The less used vegetables and those that are out of season are the most expensive of all.

Elimination of Waste in Buying and in the Kitchen. This third way to reduce food costs is the **most satisfactory** of all, since it involves NO DIMINUTION in the VARIETY, ATTRACTIVENESS, or NUTRITIVE VALUE of the menu. By **merely stopping the leaks** enough saving could frequently be effected to admit of providing an even better diet than before at less cost. Each individual must be his or her own "efficiency engineer" in discovering and stopping the particular leaks through which wastage occurs. We shall merely suggest some of the forms of wastage which occur most frequently.

In **marketing,** the SPECIALLY PREPARED and READY-COOKED foods, HIGHLY ADVERTISED brands, foods put up in SMALL PACKAGES or in EXPENSIVE CONTAINERS, are all distinctly **uneconomical** buys. The housewife who shirks the trouble of planning meals ahead, buying food in advance or doing any cooking herself, must pay dearly for the services of others in catering to her indolence. Moreover, when people get their food almost exclusively from delicatessen stores, pasteboard boxes, and tin cans or glass jars, they are almost sure to have, not only a relatively expensive, but a one-sided and unsatisfying diet as well. Buying in larger quantities, in bulk (when the food is to be thoroughly cooked so that it is sanitary to use it after handling in bulk), and using some of the less expensive and less advertised brands of foods, are always measures which make for economy.

Many persons take a special pride in getting "the best" in foods, and assume that the highest cost is synonymous with the best quality. This is

by no means always true. There is no field of merchandising where **prices vary** so much for the **same quality** article as they do for foods; that such conditions are possible is a direct reflection upon the careless and ignorant buying of many housewives. Some of the CHEAPER CUTS OF MEAT are just as NUTRITIOUS, and may be just as palatable, when properly cooked, as the more expensive ones. Sometimes the LESS EXPENSIVE TYPE of food has a better flavor and is BETTER SUITED TO THE PURPOSE for which it is to be used than a fancy brand put up in an expensive container, which necessarily adds to its cost. For example, buying extra large and perfect-shaped fruits put up in a heavy sirup (so-called "Fancy" or "Choice" brands) for the purpose of fruit salad is a waste of money, as the smaller and less sweet fruit often has a better flavor and is better adapted for salad use. Higher price is usually based on appearance and cheaper grades have the same food value. Food buyers should learn to **buy different grades of food suited to the different uses** to which they are to be put.

Those who have sufficient storage space will find a considerable saving and convenience in BUYING IN LARGER QUANTITIES. Pains taken in going to the market to see what foods may be specially LOW-PRICED ON ANY GIVEN DAY and to SELECT PERISHABLE FOODS on the basis of their quality, will pay both in money saved and in the quality of food obtained. Reasonableness in not demanding unnecessary services from the retail grocer would enable food to be sold at lower prices.

Waste in the kitchen also represents an outright money loss with no compensating return, nutritive or otherwise. Such waste may occur in a number of ways: (1) in DISCARDING portions of the food, which have nutritive value, when preparing it for the table; (2) in NOT UTILIZING LEFT-OVER FOODS properly; and (3) by allowing foods to SPOIL through improper care or refrigeration, or keeping perishable foods too long before use. Examples of food loss which come under the first head are—throwing away celery tops, outer leaves or parings of vegetables, meat bones and scraps, which are suitable for making soups; discarding meat trimmings from which the fat might be tried out, also dripping fats which might be used in cooking; burning food and careless scraping of cooking utensils in the transfer of food to serving dishes; loss of nutritive substances in the cooking water or liquid from canned vegetables, which is discarded instead of being saved for soups, sauces or gravies. Food may also be WASTED AT THE TABLE by taking too large individual portions and, in one way or another, rendering what is not eaten unfit to serve again. Failure to utilize what returns from the table to the kitchen after the meal in the making of some of the many acceptable dishes, which can be made from left-overs,

and the spoilage of food through not taking care of it properly, are both common forms of food waste which are sufficiently obvious to need no further comment.

How to Plan Adequate Diets at Different Cost Levels. Most people know that a family's meals may vary fairly widely in cost and still be entirely satisfactory for good nutrition, PROVIDED THE FOODS ARE WISELY CHOSEN. They also realize that even high-cost meals will not be adequate for body needs unless the proper assortment of foods has been included. What they need are certain rules of guidance in food selection, which will insure at least an **adequate,** and if possible an **optimal,** diet at various levels of cost. Then the individual housewife can fit the food to the family income in reasonable security that none will suffer nutritionally.

The U. S. Bureau of Home Economics has suggested plans for family diets at different levels of nutritive content and cost.[2] The plan designated as a **liberal diet** gives a wider MARGIN OF SAFETY AS TO NUTRITIVE ESSENTIALS (especially minerals and vitamins) but also requires a more liberal ALLOWANCE FOR FOOD COSTS. At this level of costs, milk may be used freely; fruits and vegetables liberally and in considerable variety; choicer cuts of meat occasionally, to give variety to less expensive meats, fish and eggs; table fat, bread, cereals, and desserts almost AD LIBITUM.[3]

In the **moderate-cost adequate diet** plan some economies have to be practiced as to choice of foods (especially kinds and cuts of meat), and the nutritional return is slightly less though it runs no risk of being inadequate in any respect. Milk, table fat, cereal foods and desserts are not curtailed; fruits, vegetables, meats, and eggs are somewhat less liberally used.

The **minimum-cost adequate diet** is just what its name implies, *i. e.*, food costs can be kept to this cost level ONLY by denying indulgence of all expensive tastes, and the nutritive content will skirt the lower margin of adequacy for body needs unless a few foods which give unusual return for the money in vitamin and mineral values are freely used. Milk is curtailed little if any, but fresh fruits and vegetables, meats and eggs are rather sparingly provided. Bread, breakfast cereals and starchy desserts, potatoes and dried legumes bulk large in this diet. Variety in the diet must be sacrificed for the sake of the special nutritive value of a few low-cost foods.

[2] Carpenter and Stiebeling, DIETS TO FIT THE FAMILY INCOME, Farmer's Bulletin No. 1757, U. S. Dept. Agriculture, 1936.

[3] These estimates as to what foods are purchasable at different cost levels are necessarily only APPROXIMATE. Food costs vary with the year, season, section of country, city or rural conditions, etc. Moreover, they assume careful marketing and control of waste. Considerably higher costs may be entailed if greater variety, choicer foods, and less economical habits enter into the picture.

TABLE XXV. WEEKLY FOOD PLANS FOR VARIOUS COST DIETS

Liberal diet.	Moderate-cost adequate diet.	Minimum-cost adequate diet.
Milk, 1 qt. daily for each child at least 1 pt. daily for for each adult	Milk, 1 qt. daily for each child 1 pt. daily for each adult	Milk, 1 qt. daily each young child ¾ qt. daily each child over 4 1 pt. daily each adult, if possible May use some as canned milks or cheese.
Vegetables and fruits, 6–7 servings daily 1 svg. potatoes 1 svg. citrus fruits or tomatoes 3 svg. other vegetables, at least half of them leafy, green, or yellow 1–2 svg. other fruits	Vegetables and fruits, 4½–5 servings daily 1 svg. (or more) potatoes 1 svg. citrus fruits or tomatoes 1 svg. leafy, green, or yellow vegetable Other vegetables 3–5 times a week Other fruits, once daily	Vegetables and fruits, 3–4 servings daily Potatoes, 9–11 svgs. weekly Citrus fruits or tomatoes, 2–3 svg. per week; juice daily for young children Leafy, green, or yellow vegetables, 5–6 svg. per week Dried beans, peas, or peanuts, 2–3 svg. per week Other fruit or vegetable 1 svg. daily
Meat, fish, or poultry Once a day, sometimes twice	Meat, fish, or poultry About 5 times a week, or daily if in combination with cereal or vegetable	Meat or fish 3–5 times per week, frequently in combination with cereal or vegetable
Eggs 4–6 per week per person; also some in cooking	Eggs 2–3 per week for adults 4–5 per week for children Includes those used in cooking	Eggs 2–3 per week per person, more if price allows
Butter or margarine At every meal	Margarine At every meal	Some table and cooking fats
Bread, cereals and desserts As needed to meet calorie requirement (or as desired if they do not displace protective foods)	Bread At every meal	Bread At every meal
	Cereal dish Once a day	Cereal dish Once or twice a day
	Desserts Once a day (twice if desired and if it does not displace protective foods)	Desserts Inexpensive ones, usually once a day

MENUS FOR TYPICAL MEALS AT THREE COST LEVELS

Liberal	Moderate-cost	Minimum-cost adequate
	SUNDAY DINNER	
Roast chicken, with savory stuffing	Stewed chicken with rice	Broiled fish or creamed salmon (canned)
Baked yams	Green beans	Potato pancakes
Creamed asparagus	Hot biscuits	Cole slaw
Head lettuce salad	Ice cream with fruit sauce	Bread and butter
Ice cream with strawberry preserves	Milk, children	Sliced bananas
Milk, children	Coffee, adults	Milk, children
Coffee, adults		Tea or coffee, adults
	WEEK-DAY DINNER	
Round steak or calves' liver and bacon	Braised beef, or beef liver	Meat and cereal loaf or tomato rabbit
French fried potatoes	Creamed potatoes	Scalloped potatoes
Broiled tomatoes	Buttered spiced carrots	Spinach or kale
Rolls	Rolls	Bread and butter
Fruit shortcake, with whipped cream	Creamy tapioca pudding	Hot gingerbread
Milk, children	Milk, children	Milk, children
Tea or coffee, adults	Coffee, adults	
	LUNCH OR SUPPER	
Cream of potato soup	Split-pea soup	Peanut butter sandwiches
Avocado-orange salad	Buttered toast	Raw carrot sticks
Whole-wheat toast	Apple salad on lettuce	Rice pudding
Cocoa for all	Milk, children	Milk for all
	Tea, adults	
	BREAKFAST	
Grapefruit, melon, or berries in season	Oranges, or baked apple	Stewed dried peaches or prunes
Cereal, children	Hot cereal with milk	Tomato juice for children
Scrambled eggs	Griddle cakes, with sirup	Fried cornmeal mush, with molasses
Toast	Milk, children	Milk, children
Milk, children	Coffee, adults	Coffee, adults
Coffee, adults		

General **weekly food plans** for these diets at **different cost levels** are given in Table XXV.[4] By scanning these food plans (from left to right), the reader can readily see the extent by which the allowances for vegetables and fruits, flesh foods, and eggs are cut down with each reduction in cost level—also the increased prominence of starchy foods in the low-cost diets.

[4] These are adapted from the 1936 government food plans as no later over-all food plans are yet available (1947). However, they have been revised in line with recent publications for families of different sizes, which are cited in references at end of this chapter. For further details and weekly market orders see these government bulletins or budget plans for different sections of the country, also cited in supplementary readings.

Attention is called to the emphasis that is placed upon leafy, green or yellow vegetables, tomatoes or citrus fruit, and dried legumes or peanuts, especially in the minimum-cost diet. It is largely through these foods, together with milk and whole grain cereals, that the quota of vitamins and mineral elements is supplied in diets at minimum cost. These facts are further illustrated and an idea is given of the TYPICAL FOOD CHOICES allowable at different cost levels by a few **specimen menus.**[5]

While surveys have shown that most families are spending only about what they need to in order to get an adequate diet and are purchasing foods which give either "good" or "fair" nutritional return for their money, it is certain that greater knowledge and care in food selection could raise the nutritional level of many families without any addition to food costs. Even at liberal levels of food expenditure, the diet is frequently below optimum nutrition standards. With greater knowledge and care in food selection, probably many diets classed as third-rate or fair could be raised to the level of "good," nutritionally speaking, without any addition to food costs.

INFLUENCES OF COOKING

"Choice of dishes does, of course, depend upon the purse. Fillet of beef costs more than corned beef. Old potatoes cost less than new. Pot-roast must be chosen by most people instead of guinea-hen; but, after all, upon the cooking depends the delectability of the higher and lower-priced dishes alike."[6]

"Someone has said that half of the digestive ills of the world are due to good cooks and the other half to bad cooks."[7]

The above quotations may serve to emphasize the two major influences of cooking upon food, namely, the pronounced effects which good or bad cookery may have upon the **palatability** and **digestibility**[8] of the food. We have enumerated the various effects of cooking processes on different types of food in some detail in Table XXVI, in order to be free to discuss the subject from a more general viewpoint in the few paragraphs which we are able to devote to it in a book of this character. Without any desire to minimize other aspects of the subject, the reader is asked to study this table and note how many of the effects detailed therein bear a direct rela-

[5] It should be pointed out that these are only sample menus to illustrate typical meals at varying cost levels. In actual practice the three meals of the day should be planned as a unit and, if possible, market orders should be made out for the week.

[6] Emily Post in Introduction to BLUE BOOK OF COOKERY by Isabel C. Smith.

[7] Dr. C. W. Lieb in EAT, DRINK AND BE HEALTHY, Day, 1928, p. 18.

[8] In this discussion, the term digestibility is used in the sense of relative EASE of digestion rather than COMPLETENESS of digestion. Many foods, which are handled with difficulty (especially in the stomach) and hence are apt to cause distress, are ultimately quite completely digested during the later stages of digestion (see pp. 324, 325, 327 and 330).

Table XXVI. Influences of Cooking

Good	Bad
1. Increases **palatability**— develops pleasing taste and appetizing flavor in such foods as meats, flour mixtures and fried foods.	1. **Carbohydrate Foods.** When insufficiently cooked, the starch grains may not be ruptured; or flour mixtures may have a doughy consistency within, so that they form soft balls which the digestive fluids cannot penetrate (hot breads, etc.).
2. Increases **wholesomeness**—heat kills bacteria and parasites which may be present in such foods as meats (especially pork), milk, cereals and vegetables.	2. **Fatty Foods.** Foods will be slow to digest and may cause digestive distress if too much fat is incorporated in, coated on, or absorbed in the food—as in rich gravies, pastries, desserts, fried foods, and fatty meats. They cause distress by slowing the emptying of the stomach, and the digestion of other foods, although the fat is usually fairly completely digested in the end.
3. Increases **digestibility**—by softening the fiber in cereals and vegetables, by rupturing the starch granules in starchy foods, by softening the texture of meats through converting connective tissue to gelatin, and sometimes by other chemical changes, *e. g.*, egg white is more digestible cooked than raw.	3. **Protein Foods.** A leathery texture may be developed by cooking these at too high temperatures, which makes it difficult for the digestive fluids to penetrate them (overcooked egg white, meats, and cheese dishes).
4. Increases **nutritive value** in some cases, though its chief influence in this direction is through its action in rendering foods more appetizing or of better texture for the digestive fluids to penetrate, and thus increasing their digestibility. Heating, as in cooking or processing foods, often produces slight chemical changes in proteins that affect their nutritive value, either favorably or unfavorably.	4. **Fiber.** When the fiber is insufficiently softened, as in underdone cereals and vegetables (especially legumes), such foods may be difficult to digest or irritating to the alimentary tract.
	5. **Inorganic Salts.** As much as half of these may be dissolved out into the cooking water and lost, in the case of boiled meats, fruits, and vegetables.
	6. **Vitamins.** The water-soluble ones (C, B_1, B_2 or G, and other B-complex vitamins) may be lost to considerable extent either by heating or solution in the cooking water. Vitamin C is readily destroyed by heating, especially if exposed to air. The other vitamins, while less easily destroyed in cooking, may be partially destroyed if food is cooked too long (especially if open to the air) or at too high temperatures.
	7. **Overcooking.** May toughen texture, spoil flavor, destroy vitamins, and develop substances that cause indigestion.

tion either to the appetizing qualities of the food or to the relative ease with which it will be digested.

One of the exceptions is the **beneficial influence** of heat through the **destruction of bacteria and parasites.** This is especially useful in the PASTEURIZATION OF MILK, which might otherwise carry disease organisms; in the thorough cooking of MEATS such as pork products which might be infected with parasites like trichinae, and hamburger steak, which is apt to contain many bacteria; the cooking of cereal products handled in bulk and of all vegetables grown on soil fertilized with excreta, in order to render them safe for consumption after possible contamination with disease germs; and in the long processing at high temperatures needed in CANNING most VEGETABLES, in order to kill the heat-resisting spore-forming organisms which come from contamination with the soil.

Another exception is the **injurious effect** which certain types of cookery have **on the mineral salt and vitamin content of foods,** thus directly affecting their nutritive value. When cooked in WATER, such foods as meats, vegetables and fruits lose a considerable amount of water-soluble flavoring substances, INORGANIC SALTS AND VITAMINS INTO THE COOKING WATER. If exposed freely to the air while cooking (open kettle cooking of vegetables), or if the heating is prolonged (as in stewing, and long processing of canned vegetables), the vitamin content of the food may be destroyed to a considerable extent. In ordinary cooking processes the destruction of vitamin is not so great, except for VITAMIN C which is rather readily DESTROYED BY HEATING in the presence of oxygen. Vitamin C, however, is relatively stable in acid solutions, and hence survives in such canned products as tomatoes, plums, and raspberries. But the addition of soda (an alkali) to vegetables, as is sometimes done to preserve their green color in cooking, causes their vitamin C content to be more readily destroyed. Soda or baking powder in doughs also facilitates destruction of vitamin B_1 in flour during baking. When the air has been completely exhausted from the cans, as is often done in commercial canning of fruits and vegetables, a considerable proportion of the vitamins, including vitamin C, may escape destruction in the subsequent heating.

In order to **protect vegetables and fruits from loss of vitamins and salts in cooking** the following suggestions are often made: STEAM them or BAKE them, instead of boiling; if boiled, DO NOT USE TOO MUCH WATER, COOK AS SHORT A TIME AS POSSIBLE to insure tenderness, and keep cover on the cooking utensil;[9] use a PRESSURE COOKER for cooking vegetables, since

[9] Use utensils of enamel-ware (or heat-proof glassware) for cooking acid fruits and vegetables, instead of metal utensils. Copper and, to a lesser extent, iron utensils hasten destruction of vitamins.

they can thus be cooked at a higher temperature but for a very short time, in their own juices, and with little air admitted. There is also extensive loss of vitamin C when vegetables are mashed or sieved and allowed to stand before serving, especially if heated while waiting. Hence, it is better to serve them in larger pieces or mash just before serving. Potatoes cooked in their skins show best retention of minerals and vitamins.

One set of experiments may be cited to demonstrate how widely the vitamin content of foods may differ according to methods of cooking used. Oser and Melnick[10] assessed the vitamin and mineral values of vegetables after cooking with (1) minimum water in a tightly covered pan (steaming) and (2) the "old-fashioned" method, boiling in lots of water in a loosely covered pan. In summarizing results by the "new" and "old" methods, they say:

> "The large losses of vitamins noted following the old-fashioned method of cooking,-averaging 31 per cent, were greatly reduced by the new-improved procedure so that on the average more than 90 per cent of these nutrients were retained. The losses of minerals in either case were not large, averaging 12 and 5 per cent, respectively."

We may turn now to note some of the more prominent examples of **how good or bad cookery affects the taste and digestibility** of foods. As to taste, we may point out the delicious and APPETIZING FLAVORS DEVELOPED DURING THE COOKING PROCESS in well-made soups and gravies, in roasted and broiled meats (or other foods cooked in their own juices), and in the crisp crusts on breads, roasts, breaded foods and those fried in deep fat. On the debit side of the ledger, as FOODS WHOSE FLAVOR HAS BEEN RUINED BY BAD COOKERY, one may cite flat-tasting, boiled meats in stews; vegetables which are either flavorless or have a disagreeably strong taste due to overcooking; pasty-tasting, undercooked sauces and cereals; and foods fried at too high temperatures, which have taken on the acrid taste of the decomposition products of the frying fat.

As the United States is a land of extremes, the extremes of good and bad cookery are often encountered, and most of us are familiar with the examples of both types cited above. Aside from the natural preference which people have for eating food that has a pleasing flavor, the appetizing or unappetizing qualities of the food exert an important influence upon digestion. The flow of saliva and gastric juice are both stimulated by appetizing tastes, and are inhibited by anything which affects the appetite adversely. In fact appetite is one of the most important factors in promoting good

[10] Oser, B. L., Melnick, D., and Oser, M., "Influence of Cooking Procedure upon Retentions of Minerals and Vitamins in Vegetables," Food Research, v. 8, p. 115 1943.

digestion (see page 323). The statement that "half of the digestive ills of the world are due to good cooks" (quoted on p. 413) is not meant to cast aspersions upon good cookery PER SE, but upon the LACK OF DISCRETION exhibited by those who love good food "not wisely but too well."

The cooking of foods may also produce **changes in texture** and other changes which directly **affect the ease with which they are digested** and the well-being of the digestive tract. Digestive upsets are often attributed to the food itself, when the method of cooking it is responsible for the distress. Foods, which are of such a texture that they are not readily reduced to fine particles by chewing, or are penetrated only with difficulty by the digestive juices, offer resistance to digestion in the stomach and pass into the intestine in undigested lumps that are likely to ferment or putrefy (due to bacterial action), or in harsh particles which irritate the intestine and may lead to diarrhea or spastic constipation. Among such products are vegetables or cereals which have a tough, woody fiber and have not been cooked enough to be thoroughly softened; meats which have become tough or dried out from cooking too long or at too high temperatures; the white of hard-boiled eggs (unless finely chopped or chewed) and overcooked, stringy cheese dishes; also the gummy inner portion of fresh or insufficiently baked bread. If care is taken to chew such foods well or if the digestive tract is not very sensitive, they may be digested without causing any apparent ill effects, because of the efficiency with which foods that escape digestion in the stomach are taken care of in the intestines. However, their digestion may place an extra strain on the alimentary tract and eventually lead to digestive disorders, while in more sensitive individuals the digestive organs may signal distress at once when called upon to handle such foods. On the other hand, foods like zwieback, toast, and hard crackers, whose crisp texture calls for considerable chewing and makes them easily penetrated by the digestive fluids, are recommended for children and invalids as being especially readily digested.

Another type of foods that are slow to digest are those that are **heavy with fat.** This is due not only to their soggy texture, but also to the specific influence which fats exert on digestion (see pp. 38 and 317). Digestive distress from fatty food is thus apt to be caused chiefly by the delayed emptying of the stomach, or by the mechanical effect of fats in SLOWING DOWN DIGESTION. When foods are properly fried, they are seared over by dropping into very hot fat, then cooked at somewhat lower temperatures, so that they do not absorb much fat during the cooking process. Foods cooked for a longer time in less hot fat will become greasy throughout and of SOGGY TEXTURE, due to ABSORBED FAT. But if the frying

fat is heated too hot, it will break down to some extent into DECOMPOSITION PRODUCTS which are at least unpleasant to taste and may be irritating to the alimentary tract. Hence it is apparent that FRIED FOODS must be cooked with skill, if they are to avoid any danger to comfortable digestion.

Other foods beside fats **develop irritating decomposition products** when heated TOO HOT or TOO LONG in cooking. A notable instance of this is seen in the digestive distress often caused by the strong-flavored substances that are developed in overcooked vegetables of the cabbage family (cabbage, cauliflower, Brussels sprouts, etc.). Coffee or tea that has taken up bitter substances through standing too long on the grounds may produce similar effects. Doubtless decomposition products are also developed in other overcooked foods. Dr. Lięb tells of a man who had indigestion whenever he ate at a certain restaurant at 2:30 P. M., but not when he ate there at 1:00 P. M. Chemical changes, of which we know little at present, may take place in foods when they are subjected to prolonged heating or to heating at very high temperatures, changes which would affect the palatability and digestibility of the food, as well as its nutritive properties. Hence, it is well to cook foods for as short a time as is required to make them palatable and digestible, and not to keep them hot for long before serving.

QUESTIONS AND PROBLEMS

1. Name five factors that influence the cost of foods. Why were food prices so low in 1933 and so high in 1947? Name five factors, other than food prices, that affect the amount which a family will have to spend to be adequately fed.

2. Give the three principal ways in which economies in the food budget may be effected. Which are especially useful for families of low income, moderate income, and higher income? Why?

3. After consulting the diagrams and text in the preceding chapter (or other reference material), list the foods (or classes of foods) that are the cheapest sources of each of the following nutritive essentials: energy, protein, calcium, iron, vitamins A, B_1, and C. Could a nutritionally satisfactory diet for a low income family be made up exclusively from these foods, and if not, why not? When there is more money to spend for food, why is a more liberal expenditure for dairy products, fruits and vegetables (and probably for meat and eggs) justifiable? Above what point is further expenditure for food not justifiable, and why?

4. Name as many ways as you can think of in which mineral or vitamin losses may occur in foods during storage or cooking. Outline the methods of storing, cooking, and serving foods best calculated to conserve their

mineral and vitamin content. Why do we not eat all foods raw? What types of food have their taste, wholesomeness, or ease of digestion improved by proper cooking, and why? Cite five instances where improper cookery renders food less readily digestible or irritating to the digestive tract.

5. Plan a day's menus for a moderately active young adult (1) at low cost, (2) at moderate cost, and (3) at liberal cost, stating size of portions eaten. Check the prices in a local market and make an approximate estimate of the cost of each of the diets planned.

6. If time permits, make a qualitative or quantitative check of the diets at different cost levels to see which gives the best return in energy value, total protein and high quality (animal) protein, minerals, and vitamins. One student or group may check cost, and others each take one of the above mentioned nutritive essentials to check. Why is cost not necessarily a measure of the nutritional value of a diet?

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CHAPTER 24

FOOD FADS AND FANCIES

IS THERE any use in attempting to meet the superstitious beliefs about food, which have been handed down to us through our ancestors and are relics of the prescientific age? In the field of diet, as in that of religion, people seem to cling to their beliefs most tenaciously and to champion them with much unreasoning prejudice. However, although by no means always REASONABLE, man is certainly a reasoning animal and, as such, is capable of shedding his prejudices and of learning the truth, so far as we know it now, about how to nourish his body suitably and efficiently.

As usual, the truth in this field is simpler than the fiction. Most of the "old wives' tales" about the special efficacy of certain foods in various diseases, or for building certain tissues, are highly fanciful and can be shown to be absurd. Here and there, of course, a few grains of truth, gleaned from experience, are discernible among the dross of superstition and are not to be discarded.

But it is just this basing of food theories upon limited personal experience which is highly dangerous. Each one feels qualified to set himself up as an authority and to dispense advice about diet to all whom he can get to listen to him, on the basis of his own experience with foods, or of observations on his relatives and friends. He KNOWS, and no one can tell him he does not, because this, that and the other thing actually happened to HIM, or to someone known personally to him. People will have to learn sooner or later that a person who knows nothing of the intricacies of food chemistry or of the complicated mechanism of the body, with its various parts interacting to influence one another, is NOT QUALIFIED TO DRAW CONCLUSIONS from his experiences with food; he is probably more apt to give the wrong interpretation than the right one, and incalcuable harm is done by those who thus draw unwarranted conclusions from scanty evidence, then close their minds to all further reasoning and endeavor to make converts to their pet theories about diet.

How Psychological Factors Influence Reactions to and Beliefs about Foods. One would think that, with the recent popular interest in

psychology, the layman would begin to realize that such factors as the power of **suggestion,** the influence of **fear,** and the desire to believe play a very important part in shaping our beliefs about food. For example, a certain food, or combination of foods, caused distress at some time because too much of it was eaten or because the conditions for digestion were poor at that time. The result may be that the same food or combination of foods actually will produce digestive trouble when it is eaten at later times. The average person concludes either that this food is especially hard for anyone to digest, or that for him this particular food "acts as poison."

It is most likely that neither of these conclusions is correct; often the truth is that the distress, though real, is brought about by **psychic influences** rather than by the food. Either the conviction that that special food always causes distress is sufficient to bring about the subsequent difficulty by suggestion (perhaps unconsciously) or the conscious fear of after-effects will so inhibit digestion that any food would disagree under such conditions. Millions of people suffer from just such "inhibitions" of being unable to eat certain foods, who could undoubtedly eat those foods in moderate amounts if they only thought they could.

Instances of the force of a **desire to believe** are seen in the pathetic credulity of people, who have ailments which they hope may be benefited by some dietary fad. Such persons are the natural prey for charlatans, who play upon both their fears and their hopes in the attempt to produce conviction that a certain remedy offers the only escape from terrible evils. Sometimes the suggestion and belief that benefit will be derived is sufficiently strong to be a force that makes for health, and the credit for recovery goes to the particular food cult followed. In other instances, no real benefit is derived but the convert is zealous enough to persist in his fad and ignore discouragements.

Commercialism Fosters Food Fads. These faddists are of two classes —those who sponsor the "eat-more" slogans and those who instill the belief that improper combinations of foods will cause dire results. The first are paid to **create a greater demand for individual foods**—eat more wheat, more meat, more sugar, more oranges, more raisins, more bran, more yeast, and so on AD INFINITUM. Each advertising agency attempts to persuade the public that the particular food that is championed has some special attributes which make it INDISPENSABLE or which justify its crowding out other foods from the diet. Although the better class of food advertising is careful not to employ overstatements and may be useful in spreading information about the nutritive values of foods, commercial advice about foods even at best is not disinterested, and when less

ethical may lend itself to gross misrepresentation of facts. There are very few foods whose place in the diet cannot be taken equally well by other foods of similar composition and no food is indispensable, except possibly milk. In general, the more VARIED the diet the more likely it is to safeguard health and, when any one food occupies too large a place, the diet is in danger of becoming one-sided.

Moreover, foods which are useful and good in smaller amounts, may do **harm** if taken **in excess,** or **under certain conditions.** The dried fruits may be of value in the diet of the individual with atonic constipation, but produce harmful irritation if too much of them is eaten or if taken by one with a sensitive intestinal membrane, as in spastic constipation, diarrhea or colitis. There is no reason for consuming raisins to the exclusion of all the other dried fruits, nor should one forget that meats and other fruits and vegetables are also excellent sources of iron. Although some persons may be benefited by the taking of bran or yeast, the prescription of such remedies (for they are not really foods) should be left to a competent physician instead of to an advertising agency, whose advice seems to be that everyone needs to take them. Harm may be done by taking either under certain conditions or in too large amounts, and the tendency is to regard them as a "cure-all." It is a characteristic of faddists to regard some one thing as a panacea for any and all ills, and the food faddist is no exception, especially when money is to be obtained by persuading people to the universal use of their product or theory.

The **theory faddists** sometimes trade on the HOPES of people, promising a variety of things dear to the human heart, so that each may find at least one pet desire in the list—*e. g.*, the purveyors of knowledge as to certain combinations of foods of which you can "eat all you want" and miraculously grow slender meanwhile, because "these foods actually consume fat." Such things are indeed too good to be true but their promoters cater to the credulity of women of ample means and figures, to whom they do not scruple to promise the impossible.

But most food cultists write to FRIGHTEN. Certain foods harmless in themselves, if taken in combination with other foods, will REACT CHEMICALLY and EXPLODE in the stomach, while other food combinations are supposed to develop mysterious TOXINS which will "poison the whole system." One is in constant danger from **wrong food combinations** or food toxins, unless one avails oneself of their knowledge of correct food combinations, to be had for a price. Many persons who should know better live in constant apprehension about food and the proper combinations of food, so that one hears about such theories AD NAUSEAM. The idea of foods react-

ing in such mysterious ways and forming explosive mixtures is entirely a creation of the lurid imagination of food cultists and there is no scientific foundation whatever for such myths, so far as we know.

How People React to Propaganda or Advice about Food. As a result of the propaganda of various food faddists, commercial or otherwise, competent and sane ADVICE about food has been discredited, since the average person does not seem able to discriminate between those who know what they are talking about and those who do not. A great many people, therefore, attach themselves to one of the following groups—(1) those who pooh-pooh all advice about diet and **eat whatever they want** with indifference or with defiance; (2) those who become **over-anxious** concerning food, and often **over-credulous** as to food theories, so that they try all the advice they can get, either at one time or in series, ending up in a sad state of mental confusion; and (3) those who become ZEALOTS, adopting some particular food fad and sticking to it with a perseverance which would be admirable in a better cause.

This chapter is written mainly in the hope (which is possibly a fond delusion) of helping some of the two latter classes of people to a **better balanced judgment** as to food theories and of reassuring some persons from misapprehensions about food. If it should also have any influence in persuading the first group, which probably outnumbers the others, that there really is a SCIENTIFIC basis for competent dietary advice, so that they would do well to give up eating entirely according to inherited tastes, appetites and prejudices, that would be an added benefit. In any event, we think the assembling of some of the current superstitions and false theories about food, with the endeavor to expose their absurdity, may be amusing even to the skeptic and interesting to those who grant to the science of nutrition some special knowledge and authority in these matters.

Truth and Fallacies about Food. This list of common fallacies about food presented on the following pages is by no means complete, and doubtless could be increased many times over by delving into the food customs and folk-lore of different nations. Likewise the scientific explanations given in the parallel column are necessarily very sketchy, due to limited space. In other words, we do not pretend that what we have offered under the heading of "Truth" represents the whole truth or is an infallible last word upon any of the subjects discussed. Our attempt has been merely to make available for the reader, in condensed form, the dictum of the BEST CURRENT SCIENTIFIC OPINION concerning these subjects, and it is possible that later investigations may necessitate the revision of some of our present-day views about nutrition.

REFUTING ERRONEOUS IDEAS ABOUT FOOD

Fallacies.	Truth.
About certain foods: Tomatoes—clear the brain —are a tonic for liver —make cancer Lemons } —aid digestion Oranges } —orange first thing in morning cures dyspepsia —cause "acid stomach" Raisins—needed by all for iron Figs, currants and strawberries—are cooling and purifying Lettuce and cucumbers—are cooling foods Lettuce—is a soporific Onions—raw onion taken at bedtime a remedy for insomnia —onion soup good for weak digestion —will cure a cold —have marked effect on circulatory system Spinach—has direct effect on kidneys Celery—is a nerve tonic or food —will cure neuralgia —is of great use in rheumatism Fish—is a brain food —leads to increased reproductive activity Meat—needed to build muscle and red blood —produces mental and physical energy —poisons the system Egg white—injurious to kidneys Nuts—have special curative properties	There is little or no foundation for the belief in the special efficacy of special foods. Most of these myths are handed down from an age which believed in "black magic," concerning foods as well as other things. They are akin to the legends that eating heart made one courageous, eating liver was good for liver complaints, etc. As has been brought out in the earlier chapters, the foods in the same food group are more or less interchangeable and the different tissues take up whatever nutritive elements they need from the blood-stream, to which common reservoir of body-building materials all the foods have contributed when they were absorbed after digestion. Special foods do not go to build special tissues. Fish does provide phosphorous-containing compounds and nervous tissue is rich in phosphorus, but meat, poultry, eggs and milk are all rich in phosphorus also and it requires a good many other elements besides phosphorus to build nervous tissues. How celery, which contains little phosphorus, became associated with special efficacy for nerves is a mystery. Meat and raisins both contain iron, but so do many other foods. It is not necessary to eat muscle tissue to build muscle any more than we need to drink blood to renew our blood supply. As to certain foods being cooling or heating, good for this or the other disease, and stimulating to special organs or parts of the body, these legends are rather obviously nonsensical, especially when they contradict each other, as they often do. Acid fruits are supposed by some to be a cure for dyspepsia and by others to cause "acid stomach." Of course the stomach secretes a digestive fluid that contains the strong mineral acid, hydrochloric acid, which is so many times more strongly acid than lemons that there is no comparison. If we did not have an acid stomach, conditions would be very ab-

REFUTING ERRONEOUS IDEAS ABOUT FOOD—(*Continued*)

Fallacies.	Truth.
	normal and unfavorable for digestion. Usually a small amount of the mild fruit acids, more or less, makes little difference in stomach acidity, though there are some abnormal conditions where it may exert an influence worth taking into account.
Cheese—should not be eaten because too hard to digest	Cheese is a highly nutritious but concentrated food. If eaten in moderate amounts along with bland foods it is well digested. Eggs are slightly more digestible cooked than raw. Bananas, when thoroughly ripe (yellow flecked with brown), are well digested even by small children. Their value in a reducing diet is due to the fact that they leave the stomach slowly, so help prevent hunger. Whether fattening or reducing depends upon the total calorie value of all foods eaten. Bananas and cream PLUS a good general diet will put weight on undernourished children, but one banana and a glass of skim milk make a convenient meal to take once or twice a day if reducing. A medium-sized banana has about the same energy value (100 C.) as a large orange.
Eggs—more digestible raw than cooked	
Bananas—are indigestible, especially for young children	
—are fattening	
—are good for reducing	
Milk—is fattening	One food is no more fattening than another except in so far as one has a higher fuel value, *i. e.*, is more concentrated as to its caloric content. 100 calories (about 2 lbs.) of lettuce would be just as fattening as 100 calories ($\frac{1}{3}$ oz.) of butter, if one could eat such a large bulk of lettuce.
—is constipating	Milk need not be constipating if enough fruits and vegetables are taken along with it. If the curd formation in the stomach causes distress, heated milk, which forms a finer curd, may be used instead of raw milk. In some cases, milk curd is irritating in the intestine and causes diarrhea; in persons allergic to it, milk may cause digestive disturbances but most normal persons digest it without difficulty. Milk has no relation, pro or con, to either syphilis or cancer.
—causes indigestion because of curd in stomach	
—helps cause cancer	
—is valuable in treatment of syphilis	
Honey, Brown sugar—natural sugars and hence better for one than cane sugar	While one may enjoy honey and brown or maple sugar for the trace of impurities which give them flavor, they are no better
Cane sugar, Beet sugar—is heating	
—injures the chest	
—makes apoplexy	

REFUTING ERRONEOUS IDEAS ABOUT FOOD—*(Continued)*

Fallacies.	Truth.
	as body fuel than cane sugar. Dark brown sugar has a fair content of iron but not much of any vitamins; honey carries some iron, and B vitamins, as well as appreciable amounts of vitamin C. However, neither is used in large enough amounts to add greatly to the mineral and vitamin content of the diet.
Highly milled grains—should never be used Whole grains—should always be used Bran—should be taken by everyone Yeast—should be taken by everyone Prunes, Figs—are "sure-cure" for constipation	EITHER highly milled cereals or whole grains are good sources of energy and protein but, if the former are used, more milk, fruits and vegetables will be needed in the diet to make up for the deficiencies of the highly milled grains (lacking in vitamins, salts and fiber). Bran, when taken in large amounts or by those with a sensitive intestine, is likely to do harm. Some doctors feel that it is unsuitable for anyone. Yeast may also cause gas distention and digestive distress in some people, and its high content of uric acid forming substances may be bad for other types of individual. Little of the B-complex vitamins is absorbed from fresh (live) yeast, but if yeast cells have been killed (as in boiled or dried yeast) the vitamins are more available and the gas-forming properties are destroyed. Both bran and yeast should be taken only under a physician's orders. Constipation is normally best combated by taking plenty of "high residue" fruits and vegetables. Dried fruits, lettuce, celery, leafy vegetables, etc. are especially useful in this respect but no special food is indispensable or represents a "sure-cure" for constipation.
About **food idiosyncrasies**: Many people think that certain foods act as "poison" to them and cause illness even when taken in small amounts. Most of these peculiar reactions to food are fancied, or are caused by the suggestion that distress will result from eating that food because it did on some previous occasion (see p. 421).	**Food Sensitization or Allergy.** A few people (less than 10 per cent probably) have real food idiosyncrasies, *i. e.*, they have at some time become sensitized to the PROTEIN in a certain food, so that whenever they get any of this food later a reaction results which may lead to the development of eczema, urticaria, wheals or itching in skin, asthma or shortness of breath, vomiting or diarrhea. This sensi-

REFUTING ERRONEOUS IDEAS ABOUT FOOD—(*Continued*)

Fallacies.	Truth.
	tization usually first develops through some irritation of the mucosa of the alimentary tract, so that it is weakened and lets some undigested protein pass through into the blood, where this acts as a foreign body and sensitizes the person to that food. It is always due to protein and is more apt to occur in children than adults. Children may outgrow a food sensitization, if that food is omitted from the diet for some time. In some cases a physician may locate what protein (or proteins) is causing the trouble and by repeated small injections of it may be able to desensitize the individual to that protein. In other cases the food idiosyncrasy is persistent and the individual has to avoid eating that particular food in any form even in small amounts. Foods which are most often responsible for true idiosyncrasies are strawberries, fish, shellfish, veal, pork, egg white, milk, cocoa, chocolate, tea, coffee, potatoes, and certain cereals (especially oatmeal, wheat and buckwheat).
About **bad combinations** of foods: Certain foods, if combined in the stomach with certain other foods, react and explode. Certain combinations of food make fat while others consume fat. Fruit should not be eaten along with any other food. The following are black-listed by different groups as being very bad combinations of foods: Lobster and ice cream Milk and cherries (or any other acid fruit) Acid fruits and starches Protein-rich foods with starches Meat with milk Two starches Two fruits Fruits with vegetables	The substances of which foods are made up are rather inert chemically, so that there is very little chemical reaction taking place between them and NO POSSIBILITY of their forming explosive mixtures in the stomach. It is absolutely impossible for any combination of foods to cause body fat to be consumed, except in so far as a diet high in protein is known to raise basal metabolism slightly (see p. 139). Any food may be fattening, if taken in excess of the body needs (see p. 338). As to the supposedly fatal food combinations, any two foods, each of which is known to be hard to digest or to retard digestion, would form a combination very likely to cause digestive distress, if eaten in any considerable amounts. Lobster and ice cream come under this head and, when eaten in quantity or by those with feeble digestion, would be apt to cause trouble. However, they do not react to form any mysterious poison and persons of robust

REFUTING ERRONEOUS IDEAS ABOUT FOOD—*(Continued)*

Fallacies.	Truth.
	digestion may be able to eat them together in moderate amounts. Two other foods hard to digest, say ham and cheese, would be equally apt to disagree if taken in large amounts and spoiled seafoods alone may cause serious digestive trouble. Large amounts of cherries taken with milk probably would cause distress, but there is no reason why persons of normal digestive abilities cannot take milk at the same meal with a moderate amount of acid fruit. The gastric juice is far more strongly acid than any acid fruit. Fruit acids are said to inhibit the digestion of starches because an alkaline medium is needed for the action of saliva. Some physiologists claim that acid fruits in the mouth really cause the secretion of a more alkaline saliva. Starch digestion is continued for some time in the stomach before its contents become acid, and is efficiently completed in the intestine, so any influence of acid fruits would be negligible. Concentrated protein foods and starches are supposed to be incompatible for the reason that protein foods are said to stimulate a greater flow of, or more highly acid, gastric juice, which stops the digestion of starches by saliva, a process which goes on only in alkaline medium. However, the presence of almost any food in the stomach (*e. g.*, carbohydrates alone) will stimulate the flow of acid gastric juice in sufficient amounts to halt the salivary digestion of starch in the stomach AFTER A MODERATE INTERVAL, and we can depend upon the efficient action of intestinal enzymes to digest any starch which escapes digestion in the mouth and stomach. It is of greater importance to chew starchy foods thoroughly than to watch carefully what type of food is eaten with them. Meat with milk is a food combination forbidden by certain religions but there are no physiological reasons against it,

REFUTING ERRONEOUS IDEAS ABOUT FOOD—*(Continued)*

Fallacies.	Truth.
	except that both are protein foods and taking too much of protein-rich foods may lead to neglect of other needed food groups. The same is true of taking two foods rich in starch at one meal—there is no incompatibility between them but smaller amounts of each should be taken or the diet is apt to be one-sided. Two fruits, or fruits and vegetables together are not taboo in any sense, but rather to be recommended, as the more fruits and vegetables eaten the better. A few people find that fruit agrees with them better when taken alone rather than with meals, but it should not be omitted from the diet. IT IS MUCH MORE IMPORTANT TO TAKE A WELL-BALANCED AND VARIED DIET THAN TO WORRY ABOUT FOOD COMBINATIONS.
Ideas about **the body**: FASTING—should never eat when have no appetite. —should not eat when sick as you feed the disease. —starve a fever and stuff a cold. —diseases will disappear if you starve long enough for the system to purify itself of toxins. CRAVINGS—should eat whatever you have a craving for as it shows the system needs it. —craving for acids means you need acids. —craving for sweets means you need sugar, etc. —dire results follow if special craving is not satisfied, especially in pregnant woman.	Appetite is no infallible guide as to what we should eat or how much. It is often greatest in certain diseases which would be benefited by a short fast or limited food intake, while in illnesses such as fevers the sick person should be fed to to prevent loss of weight and strength, since body tissues will be consumed for fuel if insufficient food is given. One to two day fasts, with water, fruit juices or green vegetables only, are often beneficial in intestinal putrefaction, overweight and high blood pressure. Longer fasts may be very ill-guided and should be taken only under a physician's advice. Some sanitariums make a dangerous fad of long fasts, which may result in acidosis, and even in death. Special cravings are likewise no guide to body needs, and can be more safely ignored than indulged. A craving usually results from lack of some food we have become accustomed to having. A child will have an abnormal desire for sweets if he has been used to them, just as one acquires a craving for alcohol, tobacco, tea and coffee, etc. The cravings of pregnancy

REFUTING ERRONEOUS IDEAS ABOUT FOOD—(*Continued*)

Fallacies.	Truth.
	are mostly fanciful and have no special significance.
Certain foods Purify the blood. Build up resistance to bacteria. Combat disease by alkalinizing effect.	Claims of purifying the blood are chiefly made by patent medicine venders or "health food" quacks. This is a vague expression which carries no scientific meaning. Normally the blood carries little or no toxic substances and the kidneys rid it of excess waste products efficiently. Claims of remarkable powers of food or medicines in promoting immunity to bacteria are likewise to be distrusted. A diet which supplies vitamins and minerals abundantly (or vitamin concentrates) will have a general effect in preventing susceptibility to infections but cannot promote immunity to specific bacteria. The influence of "alkalinizing" in preventing or overcoming infections has probably been much exaggerated. A well-balanced and varied diet is the best aid to health, and no special food (or medicine) with particular alkalinizing properties is needed.
Rôle of **Nature**: —All foods should be eaten raw as this is natural state and cooking kills nutritive substances. —No foods should be eaten raw, on account of the danger of infection with bacteria. —Should eat only foods in season or native to the region you live in, as intended so by Nature. —Milk not intended by Nature to be used as food after teeth are in.	People who follow these schools do well to spell Nature with a capital N, since they all imply that she has some special beneficent insight akin to that of the Diety. Some foods are better eaten raw and other foods are better cooked, but there is no obligation on man to eat them in the natural state. Some good foods could not be digested readily unless cooked, but cooking processes have surprisingly little effect on the extent to which foodstuffs are ultimately digested and absorbed (see p. 331). If man had been content to eat only foods as provided by Nature, without importing food from other parts of the world or raising new foods when possible, he would have had a very restricted diet and civilization would not have developed as it has. The Eskimos are a people who have certainly

REFUTING ERRONEOUS IDEAS ABOUT FOOD—(*Continued*)

Fallacies.	Truth.
	not benefited by having to live on the very limited food supply obtainable in their habitat. As for milk, the fact that it has been developed as an especially well-balanced food for maintaining life and growth during infancy, means it must be a nearly perfect food for supplying body needs in later life also.
Omitting breakfast or lunch Sleeping immediately after meals Standing fifteen minutes after meals	None of these is a practice to be recommended. Breakfast is needed after the twelve hour fast through the night, and to stimulate evacuation of the colon and avoid constipation. Lunch is needed to prevent overfatigue before evening, and the food is better handled by the body when fairly evenly divided into three meals. If there is danger of over-eating, it is better to make all three meals somewhat lighter than to omit any one meal entirely. Digestion is slowed down during sleep so it is best not to sleep soon after a meal, though lying down for a half hour after meals may favor digestion when it is weak. Standing fifteen minutes has little influence of any kind.
Drinking water with meals is bad for digestion. Smoking aids digestion. Chewing gum aids digestion.	A moderate amount of water at the beginning or with meals helps increase the flow of digestive juices and hence aids rather than hinders digestion. Smoking before or with meals inhibits hunger contractions of the stomach, but probably does not greatly influence the flow of digestive juices. In persons predisposed to gastric ulcer, smoking when the stomach is empty may be harmful. Chewing gum probably exerts no marked influence upon digestion. Certainly the amount of pepsin it contains is insignificant in comparison to the amount present in normal gastric juice.
Vegetarian Diet: —Will lead to anemia, muscular weakness and lack of vigor.	If the foods are wisely chosen, it is possible to have excellent physical development, vigor and endurance on a vegetar-

REFUTING ERRONEOUS IDEAS ABOUT FOOD—(*Continued*)

Fallacies.	Truth.
—Talented or handsome people are rarely developed on such a diet, as a preponderance of cereal food deteriorates mind and body. —Peoples on a vegetarian diet lack courage and stamina. —Freedom from the poisons contained in meats leads to a higher state of health and to greater endurance.	ian diet (*e. g.*, some of the Hindu sects). However, it is difficult to get all the elements needed by the body (especially calcium, iron, fat-soluble vitamins and complete proteins) unless some foods of animal origin are included or a large amount of leafy vegetables is taken. The human digestive tract is not well adapted to handling as large a bulk of leafy vegetables as would be needed if these foods alone had to make up the deficiencies of the cereal foods. Most so-called vegetarians get around this difficulty by including milk, cheese and eggs in the diet. These foods are excellent to supply the complete proteins, vitamins and mineral salts (especially calcium and iron) needed to supplement the strictly vegetarian diet. Many of these lacto-ovo-vegetarians find they are better off without flesh foods.
High meat diet: —Makes peoples fierce and warlike. —Produces exceptional physical and mental energy and has a rejuvenating effect. —Will necessarily lead to intestinal putrefaction, by which toxins are developed which will poison the whole system and result in disease. —Dangerous because of parasites or bacteria in meats.	On the other hand, muscle meats are foods which satisfactorily supplement the protein deficiencies (but not the calcium and vitamin A deficiencies) of the cereals and legumes. Meats also are good sources of iron and B-complex vitamins. The idea that meats are a dangerous food is erroneous. They do not contain toxins nor dangerous kinds or quantities of bacteria, provided slaughter-house inspection is as good as it usually is, and the meat has been carefully handled and well refrigerated. If thoroughly heated in cooking, any bacteria or parasites, which might be present, are killed anyway. Meats are easily digested and add to the appetizing qualities of the diet. For most people, there is no reason why they should not be used in moderate amounts. Taking an EXCESS of them may lead to intestinal putrefaction, to the formation of too many nitrogenous waste products (especially uric acid) in the body, and to a highly acid-forming and one-sided diet. Eating moderate amounts of meat does not necessarily lead to intestinal putre-

REFUTING ERRONEOUS IDEAS ABOUT FOOD—(*Continued*)

Fallacies.	Truth.
	faction any more than do moderate amounts of eggs, legumes, nuts and other protein foods. There is little, if any, evidence that the kind of food eaten directly influences the disposition or the mental and moral traits of a people. The Eskimos, who eat a diet made up almost exclusively of animal foods, are a very good-natured and peaceable race, while certain of the Far Eastern peoples who subsist almost entirely on vegetable foods are by no means lacking in courage, stamina and mental acumen. However, if the diet of a people is such as to be deficient in one or more of the nutritive essentials, that people will naturally degenerate physically, and will then show less initative and lowered morale.
Vegetable juices: —Possess greater potency in promoting health than the whole vegetables. —Different ones have SPECIFIC EFFECTS in building up along certain lines or assisting in cure of certain conditions.	Vegetables consist chiefly of water, fiber, some assimilable carbohydrate, mineral salts and vitamins (or substances like carotene from which the body can make vitamin A). The pressed out juice will contain the WATER-SOLUBLE carbohydrates, minerals and vitamins in dilute solution. Most of the fiber will be left behind and discarded, as will also that portion of the carbohydrate, mineral salts and vitamins which is not soluble in water. The substances left behind are as much needed for promoting health (especially the fiber to prevent constipation) as are those obtained in the juices. Hence, if one eats a SUFFICIENT QUANTITY of the whole vegetables, he will be just as well or better off from a nutritional standpoint than by taking the juices alone. Fruit juices are not as wasteful products as vegetable juices, since the edible portion of fruits is comparatively low in fiber anyway, and most of the carbohydrate, mineral and vitamin content is so freely soluble in water that it will be contained in the pressed-out juice. Promoters of so-called "health foods" are chiefly responsible for the idea that

REFUTING ERRONEOUS IDEAS ABOUT FOOD—(*Concluded*)

Fallacies.	Truth.
	vegetable juices have magic health-promoting qualities. Different vegetables do not have specific effects in curing diseases.
Enriched foods and vitamin concentrates: —Should be taken by most persons.	It is possible to get a plentiful supply of all the needed minerals and vitamins in the diet, if foods are properly chosen and enough foods are eaten raw or in unrefined condition. "Enriched" white bread and cereals are useful for those who cannot or will not eat whole grain bread and cereals. The added B-complex vitamins and iron partially replace the nutritive elements that were removed in milling. Margarines reinforced with vitamins A and D, as well as milk that contains extra amounts of vitamin D, are also useful. The enrichment of other foods with minerals and vitamins is probably unnecessary. Vitamin concentrates should be prescribed by a physician.

We have assumed that the reader is familiar with the subject matter and the simple scientific terms that have been given in the preceding chapters of this book, as this simplifies the explanations a great deal. The quaint wording, which is to be noted in the "fallacies" as presented, comes from the original sources from which they were drawn and is representative of the way in which the older and more untutored ideas about food were, and still are, expressed. The writer asks you to believe that, to a person with modern scientific training, most of these ideas seem as quaint as the language in which they are couched.

QUESTIONS AND PROBLEMS

1. Explain why special foods would not exert an influence on one organ or set of organs in the body, why any two foods of closely related composition have much the same effect on the nutrition of the body as a whole and why foods in the same food group (of similar composition) may be used more or less interchangeably in the diet. Give examples that illustrate the application of each of these principles in dietary planning.

2. Make a list of any prejudices that you may have against the eating of

certain foods or combinations of foods. Are these prejudices warranted in the light of facts? Are you inclined to indulge in certain well-liked foods or classes of food to the exclusion of other food groups that are needed for proper nutrition? Have you any dietary fads or fancies?

3. Talk with several other persons and make a list of any superstitions about food, prejudices against or favor for certain foods, or practice of dietary fads, which you may find among these people. Which of these may have some basis in fact and which are not based on reason? Give reasons for your conclusions.

4. Discuss the causes, whether physical, psychological or emotional, why persons develop and persist in faulty food habits or take up with food fads. Make suggestions as to ways to induce such persons to alter their food habits.

SUPPLEMENTARY READING

Selling, L. S., and Ferraro, M. A. S., THE PSYCHOLOGY OF DIET AND NUTRITION, Chap. 2, "Food Habits, Fads, Customs, and Aversions," pp. 34–54, W. W. Norton and Co., Inc., New York, 1945.

CHAPTER 25

RECENT TRENDS IN AMERICAN DIETARY HABITS

FOLLOWING the widespread introduction of machinery, the life of many nations, including the United States, has come to center less about their AGRICULTURE and more about their INDUSTRIAL production. A greater proportion of the population live in cities or large towns, while fewer people live in the country or in towns small enough to permit of their having gardens, or keeping chickens and a cow. Many women work in factories or offices, and have little time or strength for cooking. The food supply is less locally produced, and often has to be assembled from many places and brought from great distances. These facts are sufficiently prominent features of modern life that it is unnecessary to do more than enumerate them, and to point out that they are the direct result of the **machine age** or of the supplanting of an agricultural by an industrial civilization.

INFLUENCE OF INDUSTRIAL ERA UPON DIET

From the standpoint of this discussion, the important question is—what **changes** did these altered conditions produce in our **food supply** and our **dietary habits**? The alterations in the character of our national diet may be summed up under the following heads:

(1) **Cereals** came to be used chiefly in the form of highly milled products.
(2) **Sugar** formed a larger proportion of the diet than previously.
(3) More **highly refined,** canned and preserved foods were used.
(4) Too prominent a place was given to **muscle meats.**
(5) DAIRY PRODUCTS, EGGS, FRUITS and VEGETABLES tended to be used in small or moderate amounts.

Increased Production and High Milling of Cereals. These changes in food habits came about gradually in the course of the last century, and with increasing rapidity during the fifty year period 1880–1930. The introduction of farm machinery made larger production of grains possible at lower costs. There was a steady increase in the world production of wheat, corn and oats during the past century, although in the United States the per capita consumption of wheat and corn has declined since 1910 (see Fig.

77). When the great development of transportation facilities made it profitable to ship grain from all parts of the world to the great industrial centers, the problem of the KEEPING QUALITIES of grain products became an important one. In the dry, unmilled state, cereal grains can be stored for long periods without spoilage, a fact which has always made them useful as a reserve store of food. If the whole grain is milled simply by grinding, so that the germ and outer coats of the grain are incorporated in the flour, such flours tend to deteriorate in storage through the development of moulds, weevils, and insects.

This problem was met by the invention (in 1879) of the roller mill process for making **white or bolted flour.** In this process the grain is broken by crushing between successive rollers, and between crushings it is screened through bolting cloth of increasingly fine mesh. Only the white inner portion of the grain, which contains some protein but consists chiefly of starch, is fine enough to pass through the cloth at the final screening. The germ, bran and outer portions of the kernel, which contain most of the vitamins, minerals and fiber, are left behind to be used chiefly for stock feed and low grade flours. The white flour thus produced represents only about 73 per cent of the whole kernel, but it has excellent keeping qualities.

The public has been educated to associate the whiteness of flour with purity (though this whiteness is often secured by bleaching processes) and to prefer the looks, taste and spongy texture of white bread to the darker colored, closer textured breads made from whole grain flours. While a few people continued to prefer whole wheat bread, much of the so-called whole wheat bread obtainable from bakeries contained a high percentage of white flour, and the vast majority of persons ate white bread made from highly milled flour. Breakfast cereals made from highly milled grains were also popular. Since bread and cereals furnish as much as 35–40 per cent of the energy for many families in the lower income brackets and are used liberally in all diets, nutritionists became concerned by the fact that these staple foods had been deprived in processing of practically all of their mineral and vitamin content.

Increased Consumption of Sugar. We have been giving an increasingly large place in our dietary during the last century to another one-sided food, namely **sugar.** This is partly due to the increased production and economical refining processes, which have put granulated sugar on the market at prices which make it one of the cheapest forms of body fuel available (see Fig. 74, p. 403). At the same time it has excellent keeping qualities and has been incorporated in a large number of foods which are

pleasing to the palate, especially to the acquired "sweet tooth" of the American people. Sugar consumption in the United States increased TENFOLD in the last century and nearly 40 per cent between 1910 and 1930 (see chart in Fig. 77, p. 442), when it reached 124 lbs. per person annually[1] and one fifth of the total energy intake came from this one-sided food. In other words, sugar has been advanced from the position of a FLAVORING material to that of a STAPLE NUTRIENT.

Sugar is a **cheap** and **quickly utilizable fuel** but is good for nothing except to supply energy, since it is completely **lacking in body-building materials and vitamins.**

Use of Refined and Preserved Foods. In addition to white flour highly milled breakfast cereals, and cane sugar, we have come to use considerable amounts of other highly **refined foods,** such as POLISHED RICE, CORN STARCH, CORN SIRUP, GLUCOSE, VEGETABLE OILS, LARD AND LARD SUBSTITUTES, OLEOMARGARINES AND NUT-MARGARINES. All of these foods are **good for fuel** but almost totally **lacking in mineral salts and vitamins** (except as margarines have recently been reinforced by the addition of vitamin A). The development of highly refined foods has arisen partly to meet the need for foods which will keep well, partly to save work in preparing meals, and partly as a measure of food conservation (converting by-products into forms acceptable for human food).

Also the last few decades have seen the growth of an enormous **canning industry** in this country, through whose activities the SURPLUS SUPPLIES of fruits, vegetables, milk, meats and fish, produced in certain localities and at certain seasons, are preserved in some form in which they can be ECONOMICALLY TRANSPORTED for long distances and HELD FOR LATER MARKETING without spoilage. We have "tinned" fruits and fish, smoked meats, dried and canned vegetables of all sorts, and several forms of canned milk. The name of these PRESERVED products is legion, and some of them have suffered very little loss in nutritive qualities.

Also there are foods shipped for long distances and held in warehouses for long periods under commercial refrigerating processes (cold storage and quick-frosted foods). Such foods may deteriorate little or none in flavor and nutritional value, if properly stored and marketed. Refrigeration enables us to have a more constant supply of the perishable foods like meat, fish, poultry and eggs, but at the same time the VITAMIN CONTENT of foods held over long periods is always APT TO BE LESS than if eaten when

[1] The figures for total sugar consumption include not only household consumption but also amounts used by industries in bakery products, jams, canned fruits, candy, etc.

fresh. VITAMIN C is almost certain to be destroyed, either wholly or in part, by the processes of AGING, DRYING, or CANNING.

Lastly we have the **prepared food** mixtures ("self-rising" flours, pudding powders, packet gelatin desserts, etc.) and the delicatessen store products (pickles, jams and jellies, smoked and tinned meats, etc.) designed to save time and labor to the housewife, but also none too helpful to the digestion and calculated to lead to an unbalanced ration because of the consumption of too small amounts of the fresh and raw foods.

When over $\frac{1}{3}$ of our calories were taken in the form of highly milled cereals and $\frac{1}{5}$ in the form of sugar, it will be apparent that approximately one-half of our food energy would be furnished by foods which are practically devoid of vitamins. Hence, any appreciable reduction of these essential nutritive elements caused by the processes of refining, drying or canning such foods as fruits, vegetables and milk, upon which we depend heavily for our vitamin supply, might lead to nutritive disaster.

Meat Consumption. Meat is eaten in some communities and by some classes more commonly than in former years, due partly to the constant supply now rendered possible everywhere through shipment in refrigerated cars and holding in cold storage, and partly to the increased prosperity of the country, though we have always been a meat-eating nation. The industry of slaughtering and meat packing is the **largest manufacturing industry** in the United States and about ONE FOURTH **of the total expense for food goes for meats.** During the ten year period, 1930 to 1940, our meat consumption (exclusive of poultry and fish) averaged about $2\frac{1}{2}$ lbs. weekly for every man, woman, and child. The average per capita consumption of meat for the people of the world has been estimated as slightly less than 1 lb. per week. Since people in some parts of the world (notably in the Orient) get very little meat, it is evident that Americans get far more than their share of the world's meat supply, but even in this country some persons eat meat in large amounts while others get very little.

Meat, fish and poultry are good sources of protein, iron, and the B vitamins, especially niacin. Pork is a very rich source of thiamine (vitamin B_1), and liver of iron and vitamin A. Yet as a group, muscle meats are an expensive source of protein and energy, are poor in calcium and vitamin A, and after cooking have lost much of their vitamin B_1 (thiamine) and are practically devoid of vitamin C (ascorbic acid). When they form too large a proportion of the diet, there is apt to be a shortage of some or all of the nutritive essentials that are lacking in meats.

Sherman has cited dietary studies[2] made on 224 American families all at

[2] Sherman, H. C., FOOD PRODUCTS, 4th ed., Macmillan, pp. 381–382, 1948.

the same level of total expenditure for food but in three groups: (1) in which nearly half the money expended for food was for meats, (2) about one third spent for meats, and (3) only one sixth of the food money for meats. The increasing prominence of meat in the food budget, when a given sum was spent for food, meant a decreasing amount of vitamins A and C and of calcium in the dietary, with no more protein or iron and less food energy than in the diets with lower levels of meat. The latter points are due to the fact that meat is an expensive food and less of it can be bought for the money than of some other foods that provide protein, iron, and energy at lower cost. Hence we may conclude that when people of average income spend as much as one third of their food budget for meat, there is likely to be too little money left for "protective foods" such as milk, fruits and vegetables.

Dairy Products, Eggs, Fruits and Vegetables. Aside from the fact that the increased consumption of cereals, sugar and meats naturally means a lowered consumption of the other types of food, there have been independent forces at work which would cause milk, butter, eggs, fruits and vegetables to be used less freely. We have referred above to the passing of the small town era, when most families were able to have a little garden, keep a few chickens and often also one or two cows. When the days of "direct from producer to consumer" eggs, milk and garden produce are gone, these products are necessarily **more expensive,** due to expensive HANDLING by a host of shippers and middlemen before they reach the consumer. The MILK supply of large cities is sometimes drawn from several states. Costs for bottling, pasteurization and delivery form a larger proportion of the relatively high cost of milk in cities than do the amounts paid to the farmers and for shipping.

The dairy farming "belt" is chiefly localized in the northeastern and north central states, though more limited dairy interests are found in every state. The production of BUTTER and CHEESE has been taken out of the hands of the farmer and is better conducted in the creameries and cheese factories. Cheese manufacture for the nation is carried out chiefly in the two states of Wisconsin and New York. The production of EGGS, on the contrary, is widely distributed, since it is estimated that about nine tenths of all farmers in the United States keep chickens. Getting eggs to market is expensive, however, so that they have become a relatively costly food.

As to FRUITS and VEGETABLES, we have seen one of the most radical changes in our food supply in this respect. The development of REFRIGERATION PROCESSES and RAPID TRANSPORTATION both by rail and motor trucks (and recently even by airplanes), has made it possible to deliver

fresh fruits and vegetables without spoilage from coast to coast, or from Texas to Canada, in a few days' time, and has made available in city markets such a **wide range** of these foods to choose from **at almost any season** as was undreamed of twenty-five years ago. However, this service is still costly, so that the average housewife is likely to regard fresh fruits and vegetables as something of a luxury to be used in small amounts, while country households may still depend largely upon root vegetables and canned fruits in winter.

The development of extensive industries for CANNING and DRYING fruits and vegetables has done much to make these foods available for families of moderate means at comparatively LOW COST. People should take advantage of these less expensive forms of the fruit and vegetable supply. An increased demand for fresh fruits and vegetables would tend to bring larger supplies of them into the market, and hence lead to lower prices; a good example of this is seen in the citrus fruits, which have become much more plentiful and cheaper along with increased popular demand. Time was when an orange was a luxury, and this is still true in many lands.

MODERN AMERICAN DIETARY HABITS

The machine age had the effect of forcing upon the peoples of the industrial nations (especially the United States) the most gigantic human feeding experiment ever attempted. The results of this experiment, carried out through two or three generations in this country, became increasingly apparent. All of the five effects of industrial civilization upon our food habits, which were enumerated on p. 436 and discussed in the following pages, were such as to exert a deleterious influence upon nutrition and health. As a result of them the American people came to subsist in too large measure upon a diet of soft, highly refined, and concentrated foods, a diet which was predominantly acid-forming, lacking in fiber or residue, and poor in mineral salts and vitamins. Such a diet, in which meat, white bread, cereals, potatoes and sweets predominate, is likely to be **deficient in minerals** (especially calcium and iron), **roughage** and **vitamins** (especially A, B_1 and C). The ill effects of this national dietary experiment were evidenced by the prevalence of such conditions as constipation, malnutrition, poor teeth and bones, susceptibility to infections and general lowered vitality.

The above signs of dietary deficiency were sufficiently obvious and widespread as to cause concern among many who were interested in public health. As the science of nutrition developed and placed emphasis not only upon the importance of high quality protein, minerals and vitamins, but

also upon the difference between an ADEQUATE and an OPTIMUM level of diet, dietary surveys were made on a large scale to see how American diets measured up to standards. The most widely quoted of these surveys are those made by persons in the U. S. Dept. of Agriculture, the first of which was that of Stiebeling and Phipard[3] based on records of 4,000 families in 1934–36. On the basis of their figures and standards, they estimated that about one fourth of the families had diets that could be rated good, more than a third could be considered fair and another third were classed as poor.

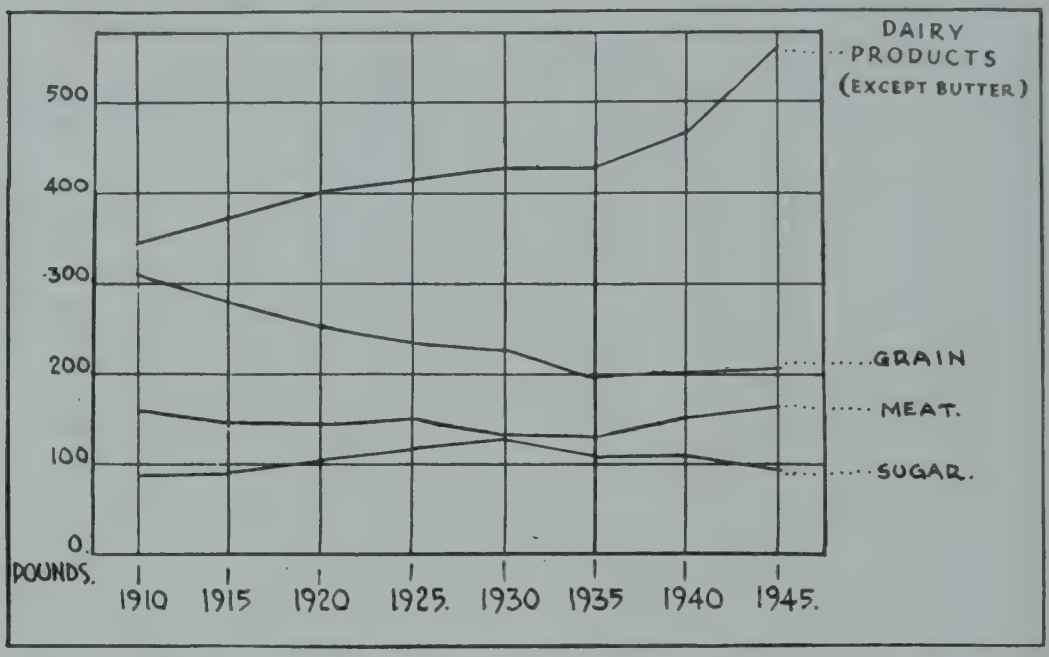


Fig. 77. These graphs show changes over 35 years in the annual consumption per person of four main classes of food, including amounts used in manufactured products. The upper curve shows consumption of milk and all milk products (other than butter), calculated in equivalent weight of fluid milk. Consumption of dairy products (except butter) has increased; the average daily consumption of milk increased from about 0.4 quart per person in 1910 to 0.7 quart in 1945. Consumption of grain products has decreased about one third in this period, while that of sugar and meats (including poultry and fish) has remained about constant.

It should be remembered that those figures were collected in time of economic depression, are for families rather than individuals, and that the "yardstick" of recommended allowances of the National Research Council was not yet available. However, later studies[4] and comparison with the 1941 recommended allowances of the National Research Council, con-

[3] Stiebeling, H. K., and Phipard, E. P., "Diets of Employed Wage Earners and Clerical Workers in Cities," 1934–36, U. S. Dept. Agric. Circ., No. 507, 1939.

[4] U. S. Dept. Agric., Misc. Pub. 405 and 452, 1941 and "Family Food Consumption in the United States," U. S. Dept. Agric. Misc. Pub. No. 550, 1944.

firmed the belief that fewer than a fourth of the families in the U. S. in 1936 were receiving diets that were nutritionally excellent. And if dietary surveys had been possible about 1900, which took into account all the vitamins that have since been discovered to be essential for health, doubtless the American diet of that day would have made an even poorer showing.

Improvements by Shifts in Consumption. Fortunately there has been a gradual change in our food habits over the past twenty years or more, which is reflected in shifts in quantities of the various food groups consumed—shifts which mean nutritional improvement of the average American diet. The charts of apparent[5] per capita consumption of the major

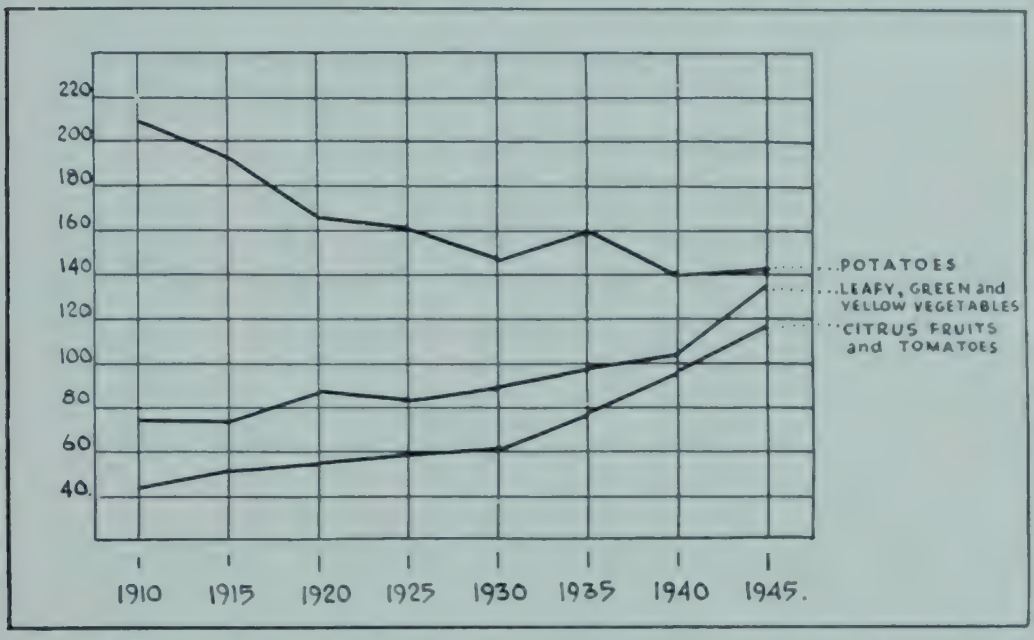


Fig. 78. Between 1910 and 1945, the annual consumption per person of potatoes decreased by about one third; that of leafy, green and yellow vegetables increased by 75 per cent; that of citrus fruits and tomatoes more than doubled during the same period.

food groups shown on pp. 442 and 443, show these trends clearly. Although there have been minor fluctuations from time to time, the quantity of meats, fats, sugar and sweets consumed is about the same now as it was in 1909, but the consumption of GRAIN PRODUCTS and POTATOES has DECREASED since that date by one third. In the same period, the consumption of EGGS has INCREASED 32 per cent, of DAIRY PRODUCTS (other than but-

[5] The term "apparent consumption" is used because the figures do not indicate all of this food was actually eaten; some may have been lost through spoilage, waste, or in other ways. Figures were obtained by adding stocks at beginning of year, total year's production and imports, subtracting ending stocks, material for non-food use and exports, then dividing the result by the number of the population.

ter) about 50 per cent, of leafy GREEN AND YELLOW VEGETABLES 75 per cent, and of CITRUS FRUIT AND TOMATOES over 150 per cent. This means that we are eating something like $1\frac{1}{2}$ times as much dairy products and $2\frac{1}{2}$ times as much citrus fruits and tomatoes as in 1909. Much of the increased production of and demand for these and other "protective foods" has come about in the last fifteen years or even less. For instance, the 1945 figures for apparent consumption were higher than the 1935–39 average, in the case of dairy products by 25 per cent, leafy green and yellow vegetables by 33 per cent, and citrus fruits and tomatoes by 40 per cent.

It does not require a nutrition expert to see that these shifts in consumption must have meant a larger intake of certain nutritive factors in which the average diet was apt to be low. The larger amounts of milk meant more calcium, high quality protein, riboflavin and other B-complex vitamins; the extra leafy, green and yellow vegetables would increase the vitamin A; the added quantities of citrus fruits and tomatoes must have brought about a greatly increased level of vitamin C in the diet. But these figures are AVERAGES and must not be taken to indicate that every person has a nutritionally adequate diet. Those in higher income groups get "the lion's share" of the total amount consumed and there is ample evidence that many individuals are still not getting an adequate diet or are below optimum standards. The poor share cropper in a Southern State may seldom see an orange, yet if he eats enough turnip greens that are not cooked to death, he may nevertheless get his quota of vitamin C.

It would seem that EDUCATION has been the chief factor in causing increased demand for these special food groups, though higher levels of wages and income have helped. The simple facts about selecting a diet that is adequate in ALL respects have been diffused through the nation through many channels—instruction in schools, school lunch programs, parent-teacher groups, Red Cross classes and instruction of industrial workers, newspaper and magazine articles, social workers, public health agencies, and government "propaganda," especially during the recent war period. There is increased interest in and appreciation of the importance of certain types of food for supplying certain food factors necessary to an adequate diet. More women are ambitious to give their families the best possible diet, as much of a surplus of vitamins and other nutritive essentials as possible. The people have become "nutrition conscious" and hence desirous of making changes in their food habits which may lead to improved health and vitality. Increased demand for certain classes of food have meant that more of these foods have been made available, sometimes at lower cost than formerly.

Improvements by Enrichment or Fortification of Staple Foods. By 1939 various nutrition experts had come to feel that a few cheap staple foods should be reinforced in nutritive value by addition of certain mineral elements and vitamins. The production of synthetic vitamins at reasonably low cost made such a program possible. These persons felt that low income groups, whose diet was most likely to be deficient as to minerals and vitamins, were the segment of the population least likely to be reached by education as to proper food choices and for economic reasons had to depend heavily on bread and other grain products. Hence in 1941 the Food and Drug Administration of the federal government recommended and established standards for the "enrichment" of white flour and bread, which were amended somewhat in 1943. The general idea was that some of the nutritive factors, which were removed in milling processes and which the average diet often contains in less than optimum amounts, should be added to the highly milled white flour. Some states have made laws that all flour and bread sold there must be of the enriched kind, and the proportion of white flour and bread that is enriched has steadily increased. Iron, thiamine, riboflavin and niacin are added to approximate the level of these substances in whole wheat products. Some breakfast cereals have additional vitamin D, as well as extra amounts of the above vitamins and iron. The housewife should look on the wrapper or package to see whether bread, flour or cereals are of the enriched variety, if she buys white bread and highly milled cereals.

It has been estimated that the enrichment of bread and cereals has increased the amount of the important (and rather scarce) vitamin B_1 (thiamine) in the American diet by about 15 per cent and appreciably added to the intake of two other B vitamins and iron. The nutritional benefits to individual consumers vary widely. Persons who eat only 2–4 slices of bread a day will get little extra vitamins or minerals in enriched bread, but to those who eat large amounts of bread and or cereals their enrichment may be an important item in improving nutrition. It should be remembered that even enriched grain products do not possess all the nutritive factors found in whole grains. Justification of the enrichment program rests on the assumption that the American people cannot be persuaded to use whole grain products. Numerous nutritionists feel that government officials and the milling industry underestimate the possibility of influencing American food habits and that the greater use of whole grain or lightly milled cereals would not only be better nutritionally but would make the world's limited wheat supply go further for human food.

It is a matter of common knowledge that margarine now contains added

vitamin A, so as to make it comparable with the more costly butter in nutritive value. Formerly 9,000 international units of vitamin A were added per pound of margarine but, since recent figures showed the AVERAGE vitamin A value of butter throughout the year to be about 15,000 I. U. per lb. better brands of margarine have been stepped up to 15,000 I. U. per lb. Purchasers should look on the carton to see the vitamin A content of different margarines. Of course the restrictive taxes upon margarine, which were secured by the dairy interests, should be repealed. Unquestionably the "fortification" of margarine with vitamin A has been a wise measure, since it makes a cheaper fat nutritionally acceptable as substitute for a more expensive one. However, the increased use of leafy, green and yellow vegetables has had a greater effect in increasing the vitamin A value of the American diet.

Milk that has had its natural low content of vitamin D increased by irradiation or other means has improved the diet, especially for infants and young children who have greater need for this vitamin than adults in order to help build strong bones and teeth. When one can get extra vitamin D in irradiated evaporated or dried milk for little or no additional cost, it is foolish not to take advantage of this "factor of safety." Fresh (fluid) vitamin D milk, if taken in sufficient quantity, will safeguard young children from rickets and at the same time provide the calcium and phosphorus needed for bone building. However, most infants and young children get vitamin D-rich cod liver oil, and ordinary milk plus cod liver oil gives full protection at lower cost.

Iodized salt has proved effective for reinforcing the diet as to iodine in certain regions where the soil, and hence the foods grown on it, are of low iodine content. In the refining of salt, the traces of iodine salts present as impurities in sea salt, are removed. So in this case also, we are restoring something lost in processing, a mineral element needed in small amounts for normal nutrition. The use of iodized salt for prevention of goiter in regions where soil and water are iodine-poor was described on p. 198.

The addition of mineral elements or vitamins to foods other than those enumerated above is not considered necessary or advisable. Usually such "reinforced" foods are unduly expensive and the quantity of additional minerals or vitamins thus obtained is insignificant. Suitable amounts of natural foods are more effective in providing all essential nutritive factors in proper proportions for promoting health.

Improvement of Food Supply by Enrichment of Soil and Crop Adjustments. Lack of space permits little more than mention of these im-

portant means of improving the quality of our food supply, which are receiving much attention now from scientists, government agencies, and even in the press. Plants draw their nourishment from the soil, so that gradually the soil becomes poorer in nitrogenous compounds and minerals with successive crops unless fertilizer is added to restore the elements that have been withdrawn. Erosion removes valuable top soil and rotation of crops, although it may help, is not enough. Plant foods grown on depleted soil are scantier in amount and lower in mineral content; animals that graze over or eat fodder grown on depleted soils are in poor condition and sometimes show deficiency diseases caused by lack of certain minerals. Persons that live in such areas and eat locally grown foods may show serious physical deterioration. Individuals and government agencies are currently campaigning for measures to improve the "fertility" of the soil, which will mean larger yields per acre and improved mineral content of the foods grown upon it. We know that the vitamin content of foods also varies considerably depending upon the strain of the plant and conditions under which it is grown. Although less is yet understood about factors that affect the vitamin content than the mineral content of foods, in time it may be possible to grow foods that carry more vitamins than the present averages.

By crop adjustments, we mean chiefly such agricultural adjustments as will lead to the production of larger quantities of food in certain food groups. Thus, the government during the war urged the use of more land for growing soybeans and peanuts, chiefly to get the oil from them at a time of fat shortage. Unfortunately, practically all of the residue after oil was pressed out, went for animal feed and people had little chance to avail themselves of the valuable protein from this large soybean and peanut crop. Over the past thirty years there has been a moderate but continuous trend to devote more land to pasturage and to keep more dairy cattle. This has meant that enough milk was available to supply the increased demand for this valuable food. It is likewise evident that increased cultivation of citrus fruits has made these foods cheaper and increased their use by the American people. Probably the diet would be further improved if somewhat more land were devoted to orchards and vegetable gardens. Popular demand for certain foods stimulates their greater production and this in turn makes more of them available at lower prices. The Department of Agriculture sets crop yields for different food groups in accordance with how much would be needed to nourish the population adequately and in this way influences the over-all food supply. Its scientists also work toward

improving breeds of cattle and poultry, introducing improved strains of wheat, corn, vegetables and fruits, and thus increasing both the quantity and quality of foods produced.

Food for the World. Much of our attention in the next few years has to be directed to the task of feeding the American people adequately and at the same time having a surplus of food to export to countries which as a result of the recent war have far less than normal food supplies. In certain parts of the world there has never been enough food for everybody to be adequately nourished or to prevent many from going hungry. The Food and Agricultural Organization of the United Nations has been formed to study world food problems of supply and demand, and to work through national nutrition organizations to appraise local conditions and endeavor to raise standards of living and of public health in less fortunate nations. Although these are long-range problems, it may be helpful to begin to shape some of our food habits in the light of world needs. For instance, the practice of "finishing" cattle for market by excessive feeding of grain in feeding lots, in order to obtain high prices for choice cuts marbled with fat, is extravagant of human food—the grain used in feed, the fat not eaten and often the less tender parts of the animal wasted. Cattle that put on weight on pasturage and small quantities of grain give better return in food value for food eaten, and dairy cattle are even more economical converters of vegetable fodder into human food. There is just not enough animal protein in the world for every inhabitant to get a desirable quota, if it were evenly distributed; in the United States, we are fortunate in having plentiful supplies of animal protein and meats. We could conserve this supply and still be well fed by doing any or all of the following things—use all edible parts of meat animals including less tender cuts and glandular organs, eat more fish, use less meat and more milk, cheese and eggs, use legumes somewhat more plentifully, especially soybeans and peanuts which have high quality protein. Such measures could make more meat available for export and, if less grain were used for animal feed, more of it would be available for hungry people in other lands.

Wheat will be the chief food which will need to be raised in large amounts and conserved for export during the next few years in order to feed the world. This is because it is economical to raise and ship, while Europeans are bread eaters but not accustomed to using corn. Our present methods of milling wheat are nutritionally uneconomical, as has been pointed out before, but doubtless they will not be altered. Industries and individuals can avoid waste, and individuals could help by eating less bread and breakfast cereals and more potatoes, which are plentiful and too perishable to ship

well. Many persons overeat and would be benefited by simply cutting down on bread and butter. However, Americans are an unbelievably wasteful people and if waste could really be eliminated, perhaps many other measures for saving food would prove unnecessary.

Safeguarding the American Diet. Years ago Sherman suggested two rules for making sure that plenty of the "protective foods" are included in the diet:

(1) At least as much should be spent for milk (including cream and cheese, if used) as for meats, poultry and fish;

(2) At least as much should be spent for fruits and vegetables as for meats, poultry and fish.

It has also been suggested that the food budget be divided in fifths—one-fifth spent on each of the following food groups: (1) meats (all classes); (2) dairy products (other than butter), (3) grain products; (4) fruits and vegetables; (5) fats, sweets and sundries.

Although both of these rules have been useful in improving the diet by encouraging the spending of a larger proportion of the food money for dairy products, fruits and vegetables, neither fits the current economic situation too well. All food prices have advanced, but meats, eggs and butter have suffered the sharpest rise in prices, and some sundries (such as coffee, which Americans consider a necessity) are also out of line in the general price increases. Hence, many families are spending more to get even a modest allowance of these items and possibly the rest of the diet may suffer. Also families which produce part of their own food supply (have a cow or vegetable garden) would not be expected to have the same distribution of cash expenditures.

While there can be no hard and fast rules, especially in such economic fluctuations as we are experiencing at present, it is helpful to compare the distribution of food expenditure between the different food groups which the average American was making in 1942 with some recently suggested plans. This has been done for one such plan in Table XXVII on p. 450, and on p. 451 will be found the distribution of food budget as recommended for low-cost diet by the Bureau of Human Nutrition and Home Economics in 1943. It will be seen that the recommended distribution of expense for different food groups is roughly $\frac{1}{4}$ for meat and eggs together, $\frac{1}{5}$–$\frac{1}{4}$ for dairy products, $\frac{1}{4}$ for vegetables and fruits (with citrus fruits, tomatoes, green and yellow vegetables prominent), and $\frac{1}{8}$ each for grain products and fats, sweets and sundries. Despite the lower cost of the last two groups, they furnish about 50 per cent of the calories; about 50 per cent of the protein is from animal sources; the major part of the mineral elements and vitamins

TABLE XXVII. DIFFERENCES BETWEEN AVERAGE AMERICAN DIETARY AND RECOMMENDED DISTRIBUTION OF FOOD EXPENDITURE

Food Groups.	Actual Distribution in Average American Diet, 1942.*		Recommended Distribution.†	
	Cost.	Fuel value.‡	Cost.	Fuel value.‡
	per cent	*per cent*	*per cent*	*per cent*
Grain products	11	30	12	33
Meats, fish and poultry	23	10	20	9
Eggs	7	3	7	3
Dairy products, except butter	17	14	22	18
Vegetables and fruits	23	15	26	17
Fats, sugar, sweets and sundries	19	28	13	20

* From studies made on family dietaries by the U. S. Dept. of Agriculture.

† As suggested by Dr. H. C. Sherman in FOODS: THEIR VALUES AND MANAGEMENT, Columbia Univ. Press, 1946.

‡ This column is merely an index of the relative return in ENERGY (calories) that is obtained from the different food groups for a given expenditure. Protein is furnished chiefly by grain products, meats, eggs, and dairy products; the distribution between animal and vegetable proteins is not much different in the actual and recommended diets, about 45 per cent from vegetable and 55 per cent from animal sources. With the recommended distribution of expenditure, grain products, dairy products (except butter), vegetables and fruits together contribute a large proportion of the calcium, iron and various vitamins, and the total amount of these nutritive essentials in the diet will be higher than with the actual distribution of expense for different food groups found in 1942.

come in return for the money spent for milk or cheese, vegetables and fruits, although whole grain cereals make a distinct contribution, especially of iron and thiamine.

What changes in food habits would be needed in order that the average American diet (left hand columns in Table XXVII) should conform more nearly to the distribution of food expenditure in the suggested plans? By and large, American families spend slightly more for meat, fish and poultry, and considerably less for dairy products (except butter) than the recommended amounts; also they appear to spend too large a proportion of their food money for fats, sweets and sundries; although the percentage spent for fruits and vegetables is not much different from the suggested

TABLE XXVIII. DISTRIBUTION OF FOOD EXPENDITURE IN U. S. DEPT. OF AGRICULTURE LOW-COST DIET PLAN, 1943
AND
PERCENTAGE RETURN OF CERTAIN NUTRITIVE FACTORS FROM DIFFERENT FOOD GROUPS*

Food Group.	Cost.	Fuel Value.	Protein.	Calcium.	Iron.	Vitamin A.	Thiamine.	Ribo-flavin.	Ascorbic Acid.
	per cent	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*
Grain products.....	13	37	34	12	37	3	44	20	
Meats, fish and poultry..	18	8	20	1	16	4	15	7	
Eggs.....	8	2	4	2	6	4	4	6	
Dairy products, except butter	25	17	27	73	9	21	12	52	17
Vegetables and fruits....	24	15	14	12	30	60	22	14	83
Fats, sugar, sweets and sundries.....	12	21	1		2	8	3	1	

* For simplicity, different classes of fruits and vegetables are grouped under one head, but the plan calls for the expenditure to be divided as follows: potatoes and sweet potatoes 5 per cent of cost, dry legumes and nuts 2 per cent, green and yellow vegetables 4 per cent, citrus fruit and tomatoes 6 per cent, other fruits and vegetables 7 per cent. The return in nutritive factors is calculated on this basis. Also, expenditures for fats, sweets and sundries in the plan call for 7 per cent of food costs for fats and oils, including bacon and salt side (which account for most of the protein and B vitamins supposed to come from this group), 2 per cent for sugar and sirups, 3 per cent spent for sundries. Tentative corrections for cooking losses were made and very small amounts of vitamin C (ascorbic acid) in certain foods were not counted, especially as they are subject to loss in cooking. The estimates for cost, fuel value and protein are more accurate than for minerals and vitamins; nevertheless the whole represents a helpful estimation of relative nutritive returns that might be expected from different food groups on an assumed cost distribution. Such estimates will vary as different articles within a food group are assumed to have been purchased.

plans, the nutritive returns from this group (minerals and vitamins) will vary according to the types of fruits and vegetables used.

We must emphasize that there can be no hard and fast recommendations as to how much families should spend for certain food groups. This will vary somewhat with income level, food prices and whether there are young children or persons with high energy needs in the family. Those with higher incomes may prefer to spend more for meats, eggs and the more expensive fats. In low-cost diets less money will go for these foods and more for grain products. The point to stress is that a fairly high proportion of the food budget must go for dairy products, fruits and vegetables, even in low-cost diets, if the diet is to be safeguarded as to minerals and vitamins; also a certain proportion must be spent for foods that furnish high quality proteins, but milk meets this requirement. When the sum spent for milk, fruits and vegetables is proportionally high, the diet will generally be better balanced and more adequate as to all of the needed nutritive factors.

QUESTIONS AND PROBLEMS

1. Which food groups were consumed plentifully by our ancestors in the agricultural era, and which were scarce? Was their diet usually satisfactory from a nutritional standpoint? If so, why and if not, in what respects was it lacking? Discuss whether or not the diets of people living on farms is now nutritionally better than that of the average city dweller, and why.

2. Name and discuss five changes in our food supply that were brought about by the industrial era, especially between 1880 and 1930. What effects did these changes in food consumption have on the health of the American people, and why? Were these effects equally noticeable in other parts of the world, and why?

3. What food groups are now consumed in larger amounts in the United States than formerly (say in 1910), which food groups do we now eat less of and of which groups has our consumption remained about the same over the last 35 years? Discuss the influence on health which these shifts in food consumption would be expected to have.

4. What proportions of the total food expenditure is recommended to be spent for the different food groups in order to secure a diet that is nutritionally satisfactory? What further shifts in food consumption would this involve if generally adopted? In times of high food costs, to what extent would it be safe nutritionally to spend a larger proportion for less expensive food groups (grain products, potatoes, cheaper fats) and a smaller proportion for high-cost food groups (meats, butter, fruits and vege-

tables)? Why is it no longer feasible to spend $\frac{1}{5}$ for cereal products; $\frac{1}{5}$ for dairy products except butter; $\frac{1}{5}$ for meat, fish, poultry and eggs; $\frac{1}{5}$ for fruits and vegetables; and $\frac{1}{5}$ for fats, sweets and sundries?

5. What shifts in our food consumption are recommended in order to conserve certain types of food for export to other nations that lack food? Will this have any adverse effect on the nutrition of people in the United States? What classes of foods need to be produced in greater quantities in order that peoples all over the world should have diets that are nutritionally adequate? How can this be accomplished? What one measure would do more than anything else to conserve food in America for use by peoples elsewhere?

6. What has soil depletion to do with nutrition? How does the apportionment of lands to the production of certain crops or types of food influence nutrition? How can the production of more and nutritionally better food on a given amount of land be accomplished? What agencies are working toward these ends?

7. What staple foods have been enriched or fortified in recent years by the addition of minerals and vitamins and why was this done? How can the losses of nutritive essentials in foods in processing be lessened? How can these losses in cooking be minimized? What natural (unprocessed) foods could we well use more of in order to increase the mineral and vitamin content of the diet?

8. Make a list of American food habits that make for poorer nutrition and those that make for better nutrition.

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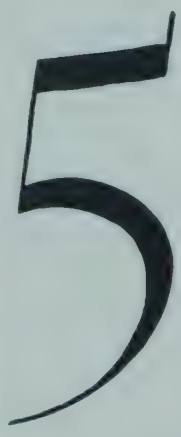
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PART



DIET FOR SPECIAL CONDITIONS

CHAPTER 26

DIET FOR CHILDREN

THUS far we have been considering the food requirements of normal adults and the best conditions for maintaining "grown-ups" in good nutrition and health. In what ways do the **nutritive requirements of children** differ from those of adults? How does their diet have to be adapted to suit their **special needs** and their more **limited digestive powers?** What changes should be gradually made in the diet of children with increasing years to adapt their food to their **increasing body needs** and digestive abilities? How may the proper food for children be **provided in the family dietary** without much special planning and extra work? We shall attempt to answer these and other related questions in the following chapter.

Feeding of Infants: FIRST AND SECOND YEARS. While each child presents individual problems at all ages, this is true to such an extent in infancy that it is difficult to generalize about infant feeding. Also this subject requires more space than can be devoted to it in a general text on nutrition and most mothers have access to a pediatrician or baby clinic for guidance during this period. Hence, discussion in this chapter is limited to the diet for children from one year of age. By the time a child is a year old, all classes of food, in simple, easily digested form, will have been incorporated in his diet so that he is getting not only milk but cereals, sieved or finely minced cooked vegetables and fruits, egg yolk and probably some meat and simple desserts—a well-balanced diet that has trained the child to like many types of food. References given at the end of this chapter include some useful books and pamphlets that deal with infant feeding in considerable detail.

SPECIAL DIETARY REQUIREMENTS OF CHILDREN

Children have different nutritional needs from adults in three respects:

(1) Their **energy requirement** per unit of weight is **higher** than that of adults.
(2) Their food should contain a **higher proportion of body-building materials** (proteins and mineral elements) and of vitamins than that of adults.
(3) Their diet should be made up of foods such as are suitable to the digestive abilities at any given age; the scope of foods that can be readily handled should increase as the child grows older.

Energy Requirements. Qualitatively the nutritional factors necessary for the child are the same as those required to nourish an adult—namely, ENERGY or fuel, PROTEIN, MINERAL SALTS, and VITAMINS, plus suitable amounts of WATER and FIBER. **Quantitatively,** however, their requirements differ.

The **basal metabolism,** *i. e.*, the amount of energy used in the internal processes of the body, is considerably **higher in youth** than in adult life. It is greatest (per unit of weight) in INFANCY and gradually decreases throughout life, except for a brief rise at the time of ADOLESCENCE (see p. 131). Second, the child is usually much **more active** than the adult, and uses a great deal of energy in work and play. Lastly, the child must have some **extra energy to grow on,** or to store in the new tissues that are being built. Camerer found that in infants as much as 15 per cent of their fuel intake and 40 per cent of their protein intake were stored in new tissue during periods of rapid growth. As the rate of growth decreases with age, the energy needed for new tissue is less and the basal metabolism is also less, though the energy used in muscular tension and activity may be greater. **Boys** usually have a higher fuel requirement than girls, due to their greater muscular tension and activity. At **adolescence,** when great muscular activity is combined with a high basal metabolism[1] and rapid rate of growth,[2] the fuel needs of boys are especially high, so that their voracious appetites at this period are justified.

Growth is most rapid during infancy; a healthy baby will usually double its birth weight in four to five months and triple it before the end of the first year. By the end of the growth period (eighteen to twenty-one years) an individual will probably have about twenty times the body weight, and more than twenty times the body protein which he had at birth.

From the figures in Table XXIX, page 459, it will be seen that the **energy requirement per unit of weight** is considerably higher in children than in adults and decreases with increasing age and size. It is highest during the first three months of life, when the infant is using nearly three times as many calories per pound as does a sedentary adult. However, the TOTAL ENERGY REQUIREMENT goes up as the child increases in body weight, and usually also in activity. The total energy needed by growing, active children may be as great as that needed by adults of considerably greater weight. Thus, the girl of fourteen may require more calories than her mother (2000

[1] DuBois found the metabolism of boys twelve to thirteen years old was 75 per cent more (per weight unit) than that of normal adults.

[2] For rapid rate of growth in boys from twelve to sixteen years, see table on p. 477.

TABLE XXIX. ENERGY NEEDS OF CHILDREN AT DIFFERENT AGES

Age.	Calories per Pound* per day.	Total per Day—Range.†	Avg. per day, for middle age of group, moderate activity.‡
Under 1 year	50–45	400–1100	110 C. per kg. (2.2 lbs.)
1– 3 yrs.	45–44	900–1400	1200
4– 6 yrs.	42–38	1100–1800	1600
7– 9 yrs.	36–34	1400–2500	2000
10–12 yrs.	33–31	1700–2800	2500
Girls, 13–15 yrs.	29–24	2000–2700	2600
16–20 yrs.	25–17	2000–2500	2400
Boys, 13–15 yrs.	31–30	2100–3600	3200
16–20 yrs.	35–18	2800–4300	3800

* From Rose's Foundations of Nutrition, 4th ed., 1944.

† Based on findings of the White House Conference on Child Health, published in GROWTH AND DEVELOPMENT OF THE CHILD, Part III, "Nutrition," Century Co., 1932.

‡ Recommended allowances of the Food and Nutrition Board, National Research Council, 1948.

The range of energy allowance for children of the same age group provides for differences not only in size but in activity, muscular tenseness, and rate of growth. Underweight or very active children need a generous energy allowance, while the caloric intake of overweight or inactive children should be in the lower range suggested for their age group (or even lower).

2700 calories), while an active, adolescent boy may use as much energy as a full grown man doing hard work (4000 calories or even more).

Need for Tissue-building Materials. The need of children for **vitamins** and **tissue-building materials** is likewise **proportionately higher** than in adults. It has been estimated that growing children usually need more than TWICE AS MUCH PROTEIN and THREE TO FOUR TIMES AS MUCH CALCIUM **per unit of body weight** as do adults.

Protein is required for building muscle tissue, as well as for the growth of the various organs, so the protein needs are highest in periods of rapid growth and decrease as children grow older. The baby of one year needs 4 grams of protein per kilogram (2.2 lbs.) body weight, the six-year-old about 2.5 grams, the adolescent boy or girl 1.5 grams, while the full grown adult requires only 1 gram per kg. for maintenance. The adult usually takes about 10 per cent of his calories in the form of proteins and this may be a safe allowance for children also, since their energy needs are relatively higher than those of adults; some nutritionists feel that somewhere BE-

TWEEN 10 AND 15 PER CENT of the calories is a safer allowance of protein for children. But QUALITY is equally important as quantity for essential amino acids should be plentifully supplied for tissue building. The adult does well if 40 per cent of his protein comes from foods of animal origin (milk and cheese, eggs, and meat) which furnish "complete" proteins. For children, probably about two-thirds (66 per cent) of the protein in the diet should be of ANIMAL origin, high quality protein that is EFFICIENT IN PROMOTING GROWTH. Cow's milk has about 19 per cent of its calories in the form of protein and the milk proteins are most efficient in supporting tissue



Fig. 79. Healthy, happy two-year-old children, whose diet has provided plenty of all the materials needed for building sturdy bodies.

building. Hence, if a child gets a quart of milk daily, it will be fairly certain to receive a safe surplus of protein in the best available form.

MILK is also the chief source in the child's dietary of **calcium** and **phosphorus,** the two elements so necessary for building strong BONES and TEETH. An allowance of about a quart of milk each day results in retention in the body of larger amounts of calcium and phosphorus needed for growth, than does a lower intake. Milk is so much richer in calcium than most foods that it is almost impossible to plan a diet which furnishes enough of this element unless at least a pint of it is used, either as beverage or in foods. The only substitute is the soybean milk prescribed for children with an allergy for cow's milk in any form.

While we can depend on milk to furnish protein, calcium and phosphorus, as well as vitamin A and riboflavin (B_2), it is apt to be **lacking** in **vitamin C** (especially if pasteurized or boiled), **vitamin D** and **iron**, and it is only a fair source of **vitamin** B_1 (thiamine). Hence children fed almost exclusively on milk often develop scurvy, rickets or anemia. It is to supply vitamin C that **fruits**, especially orange juice, are so important in the child's



Fig. 80. Good food helps to produce vivacity and charm as well as good health. (By Ewing Galloway, New York.)

dietary, while **egg yolk**, GREEN and YELLOW **vegetables** are essential as supplementary sources of iron and vitamin A, and small amounts of **cod liver oil** given throughout the growth period are a great help in supplying a surplus of vitamins A and D. Probably many children would make better growth if also given some **extra vitamin** B_1 in whole grain or "enriched" bread and cereals, or cereals with WHEAT GERM added.

We do not know just how the **vitamins** play a part in growth but ALL of

them are **necessary to promote growth** and thus are needed in the diet in proportionally LARGER AMOUNTS FOR CHILDREN than for adults. MILK, BUTTER or FORTIFIED MARGARINE, liberal amounts of FRUITS and VEGETABLES, and bread or cereals made from WHOLE GRAINS (or enriched bread and cereals) are needed to supply them. It is important that vegetables



Fig. 81. The vigorous life of an adolescent boy increases his need for energy. It should be provided through an increase in health-protective foods as well as calories. (By Ewing Galloway, New York.)

should be so cooked as to conserve their vitamin content (pp. 224-5, 415, 416). There is every reason to believe that, when a good surplus of all the growth-promoting substances and tissue-building materials is provided by the diet, a child will grow MORE RAPIDLY, will attain a LARGER SIZE, and the tissues built will be of such GOOD QUALITY as to assure health, vitality and high resistance to disease.

TABLE XXX. RECOMMENDED DAILY ALLOWANCES OF PROTEIN, CALCIUM, IRON AND VITAMINS FOR CHILDREN*

	Protein.	Calcium.	Iron.	Vitamin A.	Thiamine.	Ribo-flavin.	Niacin.	Ascorbic Acid.	Vitamin D.
Children up to 12 yrs.	grams	grams	mg.	I. U.	mg.	mg.	mg.	mg.	I. U.
Under 1 yr.	3.5 per kg.	1.0	6	1500	0.4	0.6	4	30	400
1–3 yrs.	40	1.0	7	2000	0.6	0.9	6	35	400
4– 6 yrs.	50	1.0	8	2500	0.8	1.2	8	50	400
7– 9 yrs.	60	1.0	10	3500	1.0	1.5	10	60	400
10–12 yrs.	70	1.2	12	4500	1.2	1.8	12	75	400
Children over 12 yrs.									
Girls, 13–15 yrs.	80	1.3	15	5000	1.3	2.0	13	80	400
16–20 yrs.	75	1.0	15	5000	1.2	1.8	12	80	400
Boys, 13–15 yrs.	85	1.4	15	5000	1.5	2.0	15	90	400
16–20 yrs.	100	1.4	15	6000	1.7	2.5	17	100	400

* Recommendations of Food and Nutrition Board, National Research Council, 1948. These allowances are based on the needs for the middle year in each group (as 2, 5, 8, etc.) and are for moderate activity and for average weight at the middle year of the age group.

TABLE XXXI. SUMMARY OF DIET FOR CHILDREN TWO TO EIGHTEEN YEARS OF AGE

Foods that children SHOULD NOT have	Food that children SHOULD have
Young children:	
Under-cooked cereals and soft, underdone breads	Well-cooked cereals and bread, preferably whole grain or enriched ones
Under-ripe or over-ripe fruits	Toast, rusks, hard crackers
Raw vegetables or raw fruits, with skins and seeds, not before 2 years.	Fruits—at least 2 svgs. daily, one of these citrus fruit or tomato. All kinds if properly chosen and prepared for child's age.
Thin meat or vegetable broths, as they are filling and carry little nourishment.	Vegetables—at least 2 svgs. daily, one of these a green or yellow vegetable; raw ones in moderation from 2–5 years, later use freely.
Fatty meats, oily fish, dried salt fish, shellfish, frankfurters; stews, or meats in gravies—none before 2 years, in small amounts only up to 5 years.	Potato—1 svg. daily, best baked or boiled in skin
Desserts with much fat—such as pastries, rich cakes or cookies, chocolate desserts. Simple chocolate pudding or plain ice cream may be given by end of the second year; reserve rich ice cream or that with nuts for older children.	Soups—best nourishing ones, which carry milk, vegetables, some minced meat, liver, rice or barley.
Candy, jams, and desserts with much sugar—except a little hard candy at end of meal or small amount of jam or jelly on bread occasionally.	Eggs—at least 3–5 weekly, 1 daily if possible
Foods that are hard to chew (some dry cereals, nuts, raw dried fruit, etc.), not before 2 years; popcorn, corn, raisins and whole nuts withheld if not well chewed.	Meat, fish or poultry—usually 1 svg. daily though meat substitutes (egg, legumes, or cheese), may be served several times a week. Leaner meats preferred, liver or kidney occasionally.
Pickles, olives, radishes, cucumbers and peppers not before 10–12 years.	Cheese—Cottage or cream cheese best for younger children, but may give small amounts of grated cheddar cheese in second year; older children may have larger amounts with starchy foods, if well chewed
	Desserts—Simple ones like junket, custard, jello, blanc mange, or cereal puddings are best and are the only ones allowed for young children. Moderate servings of richer deserts for older children. Use fruits often for dessert.
	Fats—best limited for young children to moderate amounts of butter or fortified margarine on bread or vegetables, thin cream and bacon. Older children may use fats more freely, but they are best used ON rather than in foods

TABLE XXXI. SUMMARY OF DIET FOR CHILDREN TWO TO EIGHTEEN YEARS OF AGE —(*Continued*)

Foods that children SHOULD NOT have	Food that children SHOULD have
At any age: Foods with much fat } use in mod- Foods with much sugar } eration Highly seasoned foods Tea, coffee, and alcoholic beverages Cocoa or chocolate } only in moder- Iced drinks } ate amounts	Salad dressings—no mayonnaise or French dressings for young children, later may use moderately Cod liver oil (or other vitamin D supplement)—1–3 tsp. daily is a "must" up to 2 yrs. and desirable for older children especially in winter. Milk—at least 1 pint, preferably 1 quart daily in some form— as beverage on cereals in cream soups in sauces, puddings, etc.

The recommended allowances for protein, calcium, iron, and various vitamins at different ages are given in the table on p. 463. The same classes of food supply these nutritive essentials for both children and adults; very young children, who are somewhat limited in their range of foods, will need proportionally more of the protein, mineral, and vitamin-bearing foods that they can take; the larger total needs that come with increasing size should be met by larger portions of food as the child grows older; foods that contribute chiefly energy (fats, starch, sugar) must not be allowed to crowd the protein, mineral and vitamin-bearing foods from the menu; in fact, the latter types of food should be prominent in menus for children in order to meet all of their nutritive requirements for growth.

Digestible Abilities. The alimentary tract of very young **infants** is not equipped to digest STARCHES and develops this ability gradually as small but slowly increasing amounts of thoroughly cooked cereals and potato are added to the diet during the first year. Babies can digest the emulsified fat in milk (and later in egg yolk) but the total amount of fat they can handle is limited, so that butter or margarine is usually not given until the second year and then in limited amounts. Infants and young children seem to have less immunity to the presence of BACTERIA in the intestinal tract, and the mucous membrane lining their alimentary tract is also more SENSITIVE TO IRRITATING SUBSTANCES than in later life. Hence, we have to take pains to keep the food as free from bacteria as possible during infancy (boil the water, pasteurize the milk, keep milk chilled, etc.), and we feed

only SOFT foods during most of the first year, straining cereals, fruits and vegetables to get rid of the rough particles. The change from puréed to finely chopped foods is usually made at 10–12 months, depending on the development of the child. Some foods to be chewed are given toward the end of the first year and gradually increased during the second year. Foods which are DIFFICULT TO MASTICATE (vegetables, meats, nuts, etc.) should be given to young children in finely minced or ground form. RAW vegetables and most raw fruits have to be introduced with caution as the digestive tract becomes stronger and the teeth are well developed (usually during the second and third years).

New foods must always be **introduced gradually,** and in case they cause difficulty should either be withdrawn entirely for the time being or given in reduced amount. It is always necessary to **guard against overcrowding the digestive tract** of young children. Their food needs are so great in proportion to their size that their digestive tracts are always carrying about as heavy a load as they can handle. This condition of an alimentary tract which is working at close to its functional capacity holds true even in older children who are growing rapidly, and is chiefly responsible for the frequency of digestive disturbances in children. Children are especially likely to have digestive distress after EATING WHEN OVERTIRED, when EMOTIONALLY UPSET, due to EATING BETWEEN MEALS, or to OVEREATING of some favorite food.

It is important to supply the child at any age generously with a VARIED, WELL-PREPARED and WELL-SELECTED DIET, which carries a maximum of nutritive value for its volume. Adolescent boys and girls can digest readily foods that may cause trouble in earlier years but their food needs are so high that it does no harm to keep to simpler foods. After all, simple, properly cooked foods are best for everyone, even for the adults in the family.

PICKLES and PRESERVES, RICH SALADS or SALAD DRESSINGS, PASTRIES, FAT MEATS and GRAVIES, heavy SWEETS, CONDIMENTS and STIMULANTS are **ruled out of the diet** during the earlier years both to SAFEGUARD DIGESTION and to AVOID CROWDING OUT the more important FOODS WHICH CARRY BODY-BUILDING MATERIALS. Because the alimentary tract does not immediately signal distress after these foods are consumed is no justification for their use, as continued abuse will probably lead to digestive troubles later, and even should the digestion be so exceptionally sturdy as to escape injury, THE REST OF THE BODY will suffer from lack of the mineral- and vitamin-bearing foods which the more elaborate and less readily digested foods displace from the diet.

FEEDING NORMAL CHILDREN: TWO TO EIGHTEEN YEARS OF AGE

Gradation of Diet to Suit Age. It will be seen from Table XXXI that the foundation of every child's diet should consist of milk and butter or fortified margarine, suitable cereals and bread, fruits and vegetables, meats, eggs and simple, nutritious desserts and soups; other foods are not necessary and for young children they should either be omitted entirely or used occasionally in relatively small amounts. The problem of adapting the diet to suit the child's age and digestive capacities thus resolves itself into only a few phases, namely:

(1) **Increasing the quantity** of some of the simple foods which formed the basis of the diet in earlier years, as the energy need grows.
(2) **Changing the form** in which these foods are given, as the digestive tract becomes equal to handling foods in rougher forms and larger particles.
(3) **Introducing new varieties** of the same type of foods.
(4) **Gradually introducing** small amounts of some of the **less easily digested foods** not allowable for young children.

The age at which certain alterations in the diet can and should be made **will vary with different children,** depending upon the general STURDINESS and ACTIVITY, RATE OF GROWTH, and especially upon the condition and FUNCTIONING OF THE ALIMENTARY TRACT. It must be understood that the suggestions given below are based on what has been found to work well for most normal children, but are not iron-clad rules. Some children may be able to take certain foods earlier than the ages indicated here; delicate children or those with digestive abnormalities, on the other hand, will have to increase the scope and quantity of their food intake more slowly than robust children. It is essential to make all changes in diet very gradually and go back to the simpler diet temporarily whenever it seems advisable to lighten the child's digestive load (*e. g.*, when a new food disagrees, or in case of illness). It should be emphasized that the simpler diets advised for younger children are adequate in respect to all of the necessary nutritive factors, and so will do just as well for an older child if a **larger quantity** is eaten.

As the child grows and develops, however, it is well to **increase the variety** of the diet and to **introduce new foods** usually as soon as the child's digestive tract can handle them successfully. The modern tendency is to introduce a considerable variety of foods into the diet even in the first year. This is done not so much because variety is needed to satisfy the child's nutritive requirements, but because it is felt that it is easier to train children to like new foods at an early age. Surprisingly enough, young children will

accept and experience no ill effects from a far wider range of foods than was formerly thought possible, provided they are offered in suitable form. The mother should not be apprehensive about introducing the child to new foods, nor force a child to take foods which at first it does not like. If the food should disagree or the child refuse it, she should let the matter drop for a time but try again in a month or so. Patient persistence and attempts to give the food in more attractive form or combined with well-liked foods work far better in training children to like many foods than nagging or undue pressure in offering a food because it is "good for you." A child should be allowed latitude in its food likes and if it takes some foods in each class or group that is all that is necessary for health. Undue attention to food may make the child unwilling to eat. In many cases of "problem children" as to eating habits, the difficulty is due to BAD HEALTH HABITS RATHER THAN TO THE FOOD ITSELF, and reform in hygiene (*e. g.*, more rest periods and sleep, more thorough chewing, stopping food between meals, less excitement, etc.) is all that is needed to bring the child back to "normalcy." When children have been trained early to eat a wider range of foods, their menus can be fitted into the family dietary earlier than otherwise, and of course a liking for most commonly used foods is an advantage throughout life.

Diet during Second Year. Probably by the time the child is one year old, it will be on a three meal a day schedule, with or without a little between meal food. The orange or tomato juice, cod liver oil, or some milk and crackers may be given between rather than with meals, if the baby seems hungry or eats its main feedings better thus, but between meal feeding should not be allowed to interfere with appetite for meals. At the age of twelve months, the baby will have become accustomed to most, if not all, of the foods that should make up the diet in the second year—cereals, dry bread, cooked fruit and vegetables (finely chopped), egg, a few meats (minced) and simple desserts. It is only necessary to increase the quantity and variety in these foods, gradually shift from minced to finely cut foods and introduce a few new types of food. Cereals ($\frac{1}{4}$–$\frac{1}{2}$ c.) twice a day, should be of whole grain or enriched variety and thoroughly cooked, although some of the partially pre-cooked ones do not require long cooking. Some of the less easily digestible vegetables can be given, mashed or chopped, but stick mostly to green or yellow ones (3–6 tbsp. twice daily) plus potato (best baked) once a day. Cooked fruit (pulp only) once or twice a day, with occasionally some raw fruit (banana, pear, peach, apple, etc.), orange or tomato juice daily. A whole egg can now be given on alternate days (or daily) and finely chopped meat (best beef, lamb, chicken or liver) from

3–7 times a week (1–1½ oz. serving). Bread should be increased from one to three pieces by the end of the year and simple desserts (jello, junket, cereal puddings and custard) may be given once a day. Children begin to want less fluid milk as they have more solid food and are growing less rapidly; they should drink AT LEAST a pint daily and more can usually be given in creamed vegetables, desserts, etc. 1–3 tsp. butter or fortified margarine spread on bread daily and cottage or cream cheese on crackers occasionally; 2–3 tsp. cod liver (or other rich source of vitamin D) is a "must" up to 2 years of age.

Three to Six Years. Use mainly the same foods as in the second year but increase the quantity, except for milk, a quart of which daily is ample throughout the growth period and which should not crowd out needed solid foods. Raw fruits may be given in wider variety, almost any kind by 5 years of age; raw vegetables should be introduced gradually, at first in small amounts (chopped), later in larger pieces to chew. Three year olds can have most kinds of meat or fish (in moderate amount—roasted or broiled, cut in small pieces), including canned fish, and by six years of age a child should be able to cut its own meat; meat, fish, poultry and glandular organs are nutritious foods but should not have so prominent a place in the diet as to destroy the liking for the blander cereal foods, vegetables, fruits, and milk.

Sweets should be limited but a wider range of desserts is allowable, *e. g.*, simple ice creams and sherbets, or small amount of simple cookies or plain cake occasionally. Fats may be used more generously; cream soups and soups that contain vegetables, rice, barley or noodles are useful dishes for variety; potatoes may be baked, boiled, mashed or creamed, and macaroni dishes used occasionally in place of potato; dry cereals may also be used occasionally. Salads may be used but without rich, highly seasoned dressings; a little mayonnaise or cheddar cheese may be used in sandwiches. If between meal snacks are needed, fruit juice or milk with crackers or bread are the best foods to give.

Six to Twelve Years. Continue the same foods which formed the basis of the diet but increase the amount of these given and widen the variety of foods taken. The choice of foods and forms in which they are taken is now nearly as wide as in the adult diet, but most of the foods in the children's diet should be carriers of either energy, protein, minerals or vitamins in order to meet their proportionately high nutritional needs.

The following foods or types of food should be included in the diet daily: 1 pint to 1 quart milk, 2–4 tbsp. butter or fortified margarine (including that used in cooking), 2–3 servings cereal or breadstuffs (more if

desired but not to crowd out other foods), at least two servings of fruit (1 citrus or tomato) with raw fruits frequently if possible, at least two servings of vegetables (1 green or yellow) with salad or raw vegetable frequently, 1 potato, meat at least on alternate days with more egg, cheese or legume on meatless days, one egg daily if possible, desserts once or twice (fruits preferable if main part of meal is not well taken).

If essential foods are eaten, appetite may control the quantity of other foods. Concentrated sweets should still be avoided, but plain cake and cookies, jelly, dried fruits and nuts, and a wide range of simple desserts may be used in moderate amounts.

Twelve to Eighteen Years. The foods given should be much the same as above but, due to the high fuel requirement at these ages, the aim should be to give highly NUTRITIOUS, CONCENTRATED foods and foods which are not likely to overburden the digestive tract.

Milk should still be kept as the main beverage and the use of tea and coffee forbidden. Cocoa forms a good beverage, if not made too strong or too sweet; chocolate is too rich to be taken as a beverage, though sweet chocolate may be used moderately as a confection.

The consumption of fruits, green vegetables and salads (with moderate amounts of ordinary dressings now) should be encouraged. Somewhat larger servings of meat are allowable, and eggs should be used freely, if possible. Potatoes, cereals, breadstuffs and simple desserts should be used freely. Sweets and fatty foods may be used more liberally but not immoderately for fear of upsetting digestion.

Too large an amount of fluids may either lead to distention of the stomach, or else spoil the appetite for the concentrated foods which are so much needed to furnish energy during this period.

Meal Plans. The arrangement of meals suited for children of different ages is illustrated in the specimen menus given on p. 471.

By or before twelve months of age the child may go on three meals a day, but will need a simple MID-MORNING or MID-AFTERNOON LUNCH, in order to avoid hunger and fatigue, at least up to three years and better up to six or seven years of age. With younger children or those inclined to be undernourished, milk or fruit juice should be given for this lunch supplemented with a small amount of bread or crisp crackers. With older children who are well nourished, this lunch may better be confined to fruit juice or some fresh fruit in season, in order to encourage them to eat well at the regular meals. When the child enters school (usually when about five or six years old), the mid-morning lunch has to be discontinued unless given

SAMPLE MENUS FOR CHILDREN AT

1–2 yrs.	3–6 yrs.	6–12 yrs.	12–18 yrs.
Breakfast 7–7:30 A. M. Tomato juice Oatmeal with top milk Whole wheat toast Milk to drink, 1 c. 9:30 A. M. Orange juice, 4 oz.	Breakfast 7–7:30 A. M. Ripe, raw pear Pettijohn's with top milk Egg, soft boiled Whole wheat toast and butter Milk to drink, 1 c.	Breakfast 7:30–8 A. M. Banana Wheatena with top milk Omelette—plain Toast and butter Milk to drink	Breakfast 7:30–8 A. M. Shredded wheat with raisin sauce (thin cream) Scrambled eggs Bacon Muffins Milk to drink
Dinner 11:30–12 A. M. Egg, soft poached Baked potato Spinach (chopped fine) Zwieback Milk to drink, 1 c. Rice pudding (no raisins)	Dinner 12–12:30 P. M. Liver and bacon Creamed potato Asparagus tips Bread—Milk to drink, 1 c. Frozen custard Plain, crisp cookies	Dinner 12:30–1 P. M. Lamb chop—broiled Mashed potato Carrots and peas Shredded raw cabbage salad Bread—Milk, 1 c. Apple tapioca pudding with thin custard sauce	Lunch 12:30–1 P. M. Cream of split pea soup Pineapple, cream cheese and nut salad Whole wheat bread Chocolate blanc mange Plain cake
2–2:30 P. M. Milk, 1 c. Graham crackers	3:00–3:30 P. M. 1 orange	Supper 6–6:30 P. M. Vegetable soup with rice Creamed celery on toast Bread—Milk 1 c. Stewed figs with cream	Dinner 6–6:30 P. M. Broiled fresh salmon Baked potato String beans Lettuce salad, French dressing Whole wheat bread Baked apple with cream Cocoa (weak)
Supper 5:30–6 P. M. Cream of wheat (enriched) with top milk Bread and butter Apple sauce	Supper 6–6:30 P. M. Macaroni and cheese Squash Toast—Milk, 1 c. Stewed prunes		

at the school, and a simple afternoon lunch is better suited to the new schedule.

Children under three are BETTER NOT FED AT THE TABLE WITH ADULTS, as the proper food for them should be restricted and the meal hours best suited to their general health are somewhat different. They rise early and should not be up long before feeding; the mid-day meal should be arranged to come just before or after the nap; and a very simple and early supper is essential to a good night's rest and to getting them to bed in season (not later than 7 P. M.). The age at which a child starts having most of his meals with the family depends a good deal on the meal schedule of the rest of the family. If the family meals are at regular and reasonable hours, a slight shift of schedule may enable the child to eat some or most of its meals with the family; in homes where there are several young children they may well continue to eat together at a small table. If there are guests for dinner or the dinner hour is late, it is best to give the child's evening meal ahead of the family.

The most SUBSTANTIAL MEAL is best given in the MIDDLE of the day, as they sleep better after an early supper of simple, easily digested foods. During school years, the noon meal frequently has to be taken away from home, and under these circumstances some arrangement should be made for SCHOOL LUNCHES which will assure at least one hot dish at the mid-day meal, while an early dinner of simple foods (6:00–6:30 P. M.) should supply a substantial hot meal at home at night. However, the food for the day should be fairly evenly distributed between three meals with no one meal unduly scanty or large.

The years from 12–18 cover the period of Junior High School and High School (with mid-day meal taken away from home), during which ADOLESCENCE and RAPID GROWTH take place, and the energy needs are accordingly very high at this time (see page 458 and Table XXIX on page 459). The menu suggested above for this period is planned to give highly nutritious FUEL FOODS without too much BULK. At the same time an effort should be made to have "tasty" and ATTRACTIVE foods in the menu, including some of the sweets and salads which are usually well liked. Though boys at this age will generally eat plenty of the simple foods, girls are likely to become finicky about food, so that it is sometimes difficult to get them to take the kind and amount of foods they really need.

The importance of **regularity of meal times** and of **not eating between meals** can scarcely be overemphasized. Probably no other single factor is so important for health unless it is the character of the food eaten. The stomach needs time to rest between meals, and habit is a strong factor in

securing the best working of the alimentary tract, which will adjust itself to secreting its digestive fluids more freely when food is taken at regular intervals and not too close together. The necessity for keeping strictly to a regular schedule of feeding has been sufficiently stressed in the case of infants so that there is apt to be greater care in this respect in the early years, but as the child grows older and especially when it comes to the family table, vigilance is relaxed and numerous "exceptions" to the rules are allowed. Too little significance is attached to having the meals of the whole family on a regular schedule. If between meal feeding is needed, as for young or undernourished children, the mid-morning or afternoon lunch should be at a regular hour (not too near mealtime) and should consist of simple, nourishing foods that will leave the stomach before the next meal. Between meal feeding does no good if it results in less food being taken at meal times.

Cultivating the **right habits of eating** and the **proper attitude toward food** is also an important part of a mother's task in training her children. Children must be watched and taught from the first not to eat HURRIEDLY nor to DAWDLE at the table, not to take too LARGE MOUTHFULS, not to swallow their food until it is well CHEWED, and not to WASH FOOD DOWN WITH FLUIDS. Sometimes a single one of these bad habits of eating will be responsible for digestive difficulties which cause the child to be undernourished. Carefulness is needed to see that the child does not work or play too hard, so that he comes to meals too excited or too tired to eat. **Overfatigue** and **strong emotions** retard digestion (see pp. 305, 328), so introduce REST PERIODS BEFORE MEALS, if necessary, and do not SCOLD OR PUNISH a child at mealtime. Give some HARD FOOD at each meal to encourage chewing and to exercise the teeth and gums; give WATER liberally between meals but only moderately at mealtime; give only moderate amounts of ICED BEVERAGES OR DESSERTS with meals and prohibit, or at least greatly restrict, access to the "soda fountain" between meals.

Candy should not be given to children, except for small amounts of some simple candy (the hard ones are best) at the end of a meal on special occasions. The craving for sweets is a habit all too easily cultivated, and the reasons why it is a kindness to keep them from children are—

(1) they cloy the **appetite** and pervert the **taste** so that the bland foods (milk, cereals and vegetables), which contain the nutritive factors essential for growth, are apt to be refused;

(2) concentrated sweets are likely to **ferment** or cause irritation in the **digestive tract**;

(3) the **teeth** and **bones** of candy-eating children are often poor because the sweets are lacking in bone-building elements and crowd out of the diet those foods which do

contribute to the building of strong bone tissue also sweets left about the teeth ferment and may act locally to cause tooth decay;

(4) the eating of sweets may lead to **overweight,** which has numerous undesirable consequences.

Accustom the child to having the food only sparingly seasoned with sugar or salt. It is the duty of an adult, who is responsible for the well-being of a child, to see that the proper amounts of "protective foods" and of the foods essential for tissue-building or growth, are consumed before **desserts** are allowed.

No greater **favor** can be done for the child than to train it to realize which foods are ESSENTIAL, to cultivate a liking for a WIDE RANGE of these foods in the early years, and, in general, to inculcate both by precept and practice an attitude toward food which will make for health and happiness in later years.

Planning the Family Dietary Around That of the Children. The menus given on p. 471 are meant to suggest how the food plans for children may be varied at different ages, but not that the different age groups should have different meals. Obviously the family menus should be planned to include both the children and adults. This can be done satisfactorily in only one way, *i. e.*, by using as the FOUNDATION OF THE ADULTS' DIET THE SIMPLE, EASILY DIGESTED FOODS which should form the basis of the CHILDREN'S MEALS. In the ordinary household, it means a prohibitive amount of labor to prepare entirely different diets for the children and adults. A few extra dishes may be served for the elders, which are forbidden to children, but the morale of the children will be much better if they are not tempted to ask for other foods by seeing them served at the table. A child is very apt to feel abused at being refused certain dishes, or to resent being made to eat what its elders are exempted from eating; on the other hand, children are prone to imitate those they look up to, and frequently take the cue as to their likes and dislikes in foods from their parents' habits in this respect.

This should not entail any great hardship on the parents; the foods which are best for children are those which are best for adults, and their own health will undoubtedly benefit by refraining from the less digestible foods and taking plenty of the mineral- and vitamin-bearing foods such as milk, fruits and vegetables. The meals suggested on p. 471 as suitable for children over three years of age do not seem unattractive to adults nor very different from what they might choose, except that the suppers are lighter than most adults prefer, while milk is the main beverage and tea or coffee

are ruled out. An example of a family menu which can be adapted to suit the needs of both adults and young children is given below.

Breakfast	Lunch
Grapefruit juice (canned)	Creamed eggs on toast
Dark farina with milk	String beans
Toast Margarine	Jellied fruit salad
Milk for children	Oatmeal cookies
Coffee for adults	Milk

Dinner

Baked shoulder of lamb
Baked sweet potato Green peas
Green salad
Bread Margarine
Apple Brown Betty
(baked)
Milk for children

This is a fairly economical day's menu that does not involve too much work for the mother of young children. A child of two years or three may have the grapefruit juice slightly diluted (if desired), the string beans and meat (small portion) finely cut, the peas and sweet potato mashed and omit the green salad. The jellied fruit salad may be made with finely cut canned fruit and salad dressing left off it for the young children; it may be prepared beforehand and at a time convenient to the mother. The oven-cooked dinner is likewise a labor-saver and gives a wholesome, satisfying meal for the adults and older children; the pudding is suitable for all ages if not too sweet or heavily seasoned; any other oven-cooked dessert, suitable for children, could be substituted if desired or white potatoes used instead of sweet potatoes, since green vegetables are well represented in the meals. The green salad should have a simple dressing (lemon juice, French or boiled dressing) and children over three years may be given young greens, finely cut or to nibble on. Another relatively inexpensive meat or a left-over meat dish might take the place of the baked lamb, and soft-cooked eggs or creamed fish substitute for the main luncheon dish. The more substantial meal might be served at mid-day and the luncheon menu used as supper, if this arrangment is better suited to the children and fits into the living schedule of the adults.

It is essential to family harmony and ease in planning meals for the group that ALL SHOULD BE WILLING TO EAT SOME OF ALMOST ANY FOOD OFFERED. While it is not advisable to force one to eat much of an unacceptable food at one time nor necessary to eat any food for which one has a strong dislike, provided other similar foods from the same group can be

substituted, such aversions to special foods cause a great deal of extra trouble, and the ability to eat a wide range of foods makes for a well-balanced diet, and hence for good nutrition. Adults should be careful not to make disparaging remarks about certain foods before children. If everyone is accustomed to eat cheerfully at least a small amount of all the foods which come on the table, a better ESPRIT DE CORPS and saner attitude toward food will prevail. One will be surprised in such an atmosphere to see how food prejudices are gradually overcome and what it is possible to accomplish in learning to like many useful foods.

HOW TO TELL WHETHER NUTRITIONAL NEEDS OF CHILDREN ARE BEING MET

Every mother is anxious to have **assurance** that she is giving her child the **right kinds** and **amount** of food, yet few have the ability, time or inclination to keep an exact record of what the child eats, calculate its calorie intake, and compare this with the estimated amount of fuel food which a child of that age should require. Fortunately such a careful checking of calorie intake is not necessary, unless the child is ill or persistently undernourished so that a special diet has to be planned for it.

We have two criteria for judging when an ADULT'S diet is well adjusted to balance his nutritional needs—namely, maintenance of a state of positive HEALTH and of STATIONARY WEIGHT (see p. 123). The same general indices of the nutritive condition are what we should watch in children, only with modifications due to the fact that their food should provide for satisfactory growth and not just for maintenance. CHILDREN should not remain stationary in weight but should be making **consistent gains in weight** (and height) throughout the growth period, though not always at a constant rate for it is normal for growth to proceed more rapidly at certain periods than at others. Infants should be weighed at least once a month and older children at regular intervals. While the monthly gain may not be regular, the weight should not remain stationary more than two months, provided the child is being properly fed and there are no abnormal conditions to keep it from gaining.

Weight Gains. AT WHAT RATE SHOULD CHILDREN BE GAINING WEIGHT (and height), if the food is furnishing plenty of vitamins, building materials and calories for them to make the normal gains? Table XXXII, compiled from a number of different sources and representing the AVERAGE figures obtained from weighing a great many apparently normal American children, will help to answer this question.

It will be noted that the **periods of most rapid growth** are (1) during

TABLE XXXII. AVERAGE WEIGHT GAINS OF NORMAL CHILDREN AT DIFFERENT AGES

Boys.			Girls.		
Age, *years.*	Approximate average gain.		Age, *years.*	Approximate average gain.	
	Per month, *ounces.*	Per year, *pounds.*		Per month, *ounces.*	Per year, *pounds.*
0–1	16	11–13	0–1	16	11–13
1–2	7	6	1–2	7	5½
2–3	6	5	2–3	6	4½
3–8	6	Average gain of about 4½ lbs. per year	3–8	6	Average gain of about 4½ lbs. per year
8–12	8		8–11	8	
12–14	12	9	11–14	12	10
14–16	16	13	14–16	8	7
16–18	8	6	16–18	4	3

the FIRST YEAR, after which there is a gradual decline of rate of growth through the second and third years, (2) between the ages of ELEVEN TO FOURTEEN FOR GIRLS and FOURTEEN TO SIXTEEN FOR BOYS. The rate of growth begins to be accelerated about the eighth year, reaches a maximum during the years of adolescence, which are slightly earlier for girls than for boys as noted above, and then gradually declines until growth ceases.

It should be emphasized that, if a child is getting ENOUGH CALORIES, BODY-BUILDING MATERIALS (proteins, mineral salts, etc.) and VITAMINS in its food, it will grow at approximately normal rate **unless something else is holding it back.** When a child is not making satisfactory gains, one should first look carefully to see if there is not a deficiency in food intake with respect to some of the nutritive factors (capitalized above) which are needed for growth. If an honest facing of facts can disclose no possible DEFICIENCY IN THE FOOD SUPPLY and no BAD HEALTH HABITS which make for poor nutrition (irregular meals, late bedtime, overfatigue, bolting food, etc.), then a physician should be consulted to see if he cannot locate the factor which is keeping the child from gaining—usually some defect like ADENOIDS, INFECTED TONSILS OR TEETH, other INFECTIONS, or some DIGESTIVE DISORDER. There is always a reason (more often several), which can be discovered by persistent search and the correction of which should leave the child free to gain.

Usually **appetite** will lead a child to take sufficient food to make fair

gains in weight. However, appetite is **not a safe guide** to follow under all conditions for the following reasons:

(1) Bad health **habits or physical defects** may result in a POOR, FINICKY or IRREGULAR appetite. There may be emotional or psychological reasons why a child refuses certain foods or shows little appetite for food.

(2) Appetite controls the **quantity** of food consumed but the **selection** of foods may be such that the diet will be lacking in one or more essentials, *e. g.*, efficient proteins, mineral elements or vitamins.

(3) A FAIR gain may be made and yet even **better gains be possible, if the diet were improved** either as to SELECTION or QUANTITY.

It is probably true that, although the figures given in Table XXXII on p. 477, represent the AVERAGE gains made by supposedly normal children, BETTER gains could be made and children could grow to a LARGER SIZE, provided the very **best kind of diet** were furnished them and all conditions for nutrition made as favorable as possible. For further details as to correcting CONDITIONS so as to favor weight gains see the chapter on MALNUTRITION (pp. 529–547).

On the other hand, children of different types of body build normally do not show the same rate of gains in weight and height.[3] A child of tall build may gain more in height and less in weight than the average, while one of short, stocky build inclines to gains in weight rather than in height. If weight gains are at least moderate and consistently sustained, and the child is in good health, the mother should not worry too much because her child does not conform to the average pattern.

General Nutritive Condition. It is essential to do more than watch for gains in weight and height in order to insure satisfactory nutrition in a child. As with the adult, no diet can be called satisfactory which does not lead to a state of positive **health** and abundant **vitality.**

We all know the type of child who eats gluttonously, especially of SWEETS and STARCHY FOODS, and is OVERWEIGHT for his years and height, yet who is INACTIVE physically (and sometimes mentally as well) and is likely to have FLABBY FLESH, POOR BONES and TEETH, or to be ANEMIC. Such a child has been getting **too much fuel** and **too little tissue-building materials** (especially calcium and iron) **and vitamins** in his diet to build sound tissues and make for good health. The extra fuel caused him to gain in weight but was deposited as excess fat, which is a burden rather than an asset.

[3] Maintaining the proper ratio of weight to height is more important than making certain weight gains at a given age. This will be taken up more fully in the chapter on malnutrition, and tables will be found in the Appendix (pp. 576–581) giving the average weight of boys and girls at different heights.

The **reverse type of malnourished child** is the THIN, NERVOUS, OVER-ACTIVE, OVERSTIMULATED type, who is UNDERWEIGHT for his height, fatigues easily, is irritable, tense, and liable to digestive difficulties. Such a child may go on growing in height on a food supply which is inadequate to meet its needs both for activity and for building new tissues. Either type



Fig. 82. Contrast between two European children, stunted because of inadequate diets, and a well-developed American boy of the same age (eight years). Note the strained expressions and unhealthy appearance of the two poorly fed children, as well as their smaller size. (New York Times, World Wide Photos.)

of poorly nourished child may be ANEMIC and especially SUBJECT TO INFECTIONS, when the diet has provided an insufficient amount of iron or vitamins.

Between these two types comes the **well-nourished child**, the amount and selection of whose food has been such as to furnish ALL the elements needed to build a GOOD-SIZED, WELL-PROPORTIONED BODY, with FIRM MUSCLES, SOUND BONES AND TEETH, plenty of RED CORPUSCLES in the

blood, a DIGESTIVE TRACT which functions so smoothly that it is overlooked, high RESISTANCE to bacterial infections, a STABLE NERVOUS SYSTEM and HAPPY DISPOSITION.

Figure 82 (p. 479) shows the **striking contrast** between such a healthy, WELL-NOURISHED boy of eight years, and two badly UNDERNOURISHED children of the same age. The malnourished children have not only been



Fig. 83. A difference of five years in age and of four pounds in weight. Paul is eight years old and weighs 33 pounds; his brother Ralph is three and weighs 29 pounds. Paul is stunted both in height and in weight because of improper food habits. He did not take enough food; did not like milk, bread, butter, fish or meat; he washed his food down with liquids and he was allowed to sit at the table and play with his food while the others were eating. His mother says he is "irritable and cranky," Ralph, on the other hand, is strong, good-natured and happy. (From Emerson, "Nutrition and Growth in Children," D. Appleton and Co., Publishers.)

unable to make suitable gains in weight and height, but their drawn and anxious look, pallor, and poor muscular and skeletal development all denote LOW VITALITY and a state of ILL HEALTH, for which the inadequate diet available under war conditions was responsible. Figure 83 (above) also shows a similar contrast in weight and state of health due to the different food habits of two brothers.

A mother will do well to keep in mind the standard of attaining abundant health and vitality for her children when judging whether they are taking the best possible diet. The task of training a child to consume the proper diet becomes more rewarding, when she realizes that this is one of the chief factors in building health and happiness for the child, both in the present and the future.

QUESTIONS AND PROBLEMS

1. Explain why the requirements of children for energy, protein, mineral elements and vitamins are relatively higher per unit of body weight than those of adults. What factors determine their total requirements for these nutritive essentials, and are their total requirements necessarily higher than those of adults?

2. What are the chief criteria for telling whether a child, at any age, is properly nourished?

3. Outline the types of diet best suited for children from 1–2 years, 3–6 years, 6–12 years, 12–18 years, including any vitamin supplements that are needed.

4. Make a day's menus for a four-year-old child, who will drink little milk.

5. Make a day's menus for an adolescent girl, who is disinclined to eat because she wants to keep slender; for an adolescent boy, who is always hungry.

6. Make a day's menus for a family of two adults and children who are three, seven, and twelve years of age. Plan the meals to be moderate cost and with most of the foods suitable for all members of the family (with slight modifications), yet to include all the kinds and amounts of foods listed in the table on pp. 464–5 (right-hand column) as needed by children for good nutrition and growth.

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CHAPTER 27

DIET FOR PREGNANT AND NURSING MOTHERS

INFLUENCE OF DIET ON FERTILITY. It has often been shown by experiments on animals that ANY PROLONGED **deficiency in the diet** will have an **unfavorable influence on fertility,** either leading to sterility, resulting in a small number of stillborn or feeble offspring, or causing inability of the female to produce milk for the young. Such failures in reproduction may result from restricted diets low in fuel value, from diets too low in protein, in mineral salts, or in vitamins. An illustration of reproductive failure due to lack of iodine in the mother's diet (Fig. 21) was given on p. 196. The disastrous result of shortage of vitamin A, calcium and sodium chloride in an all wheat ration for cattle and satisfactory reproduction on the properly supplemented ration are shown in the accompanying pictures (Figs. 84, 85).

Mechanism by Which Child Is Nourished through Mother. The human embryo grows from a weight of less than 1 grain (0.065 gm.) to an infant of approximately 7 lbs. by means of **materials furnished** to it **from the blood stream** of the mother. There is no direct connection between the maternal circulation and that of the child, but **interchange occurs through the placenta,** a vascular organ on the inner surface of the uterus, which is connected with the fetal circulation through the umbilical cord (see Fig. 86, p. 485). Hence, all food elements are taken up by the fetus in the simple forms in which they are carried in the blood following complete digestion, and are built into the more complex substances needed to form bone, muscle, and other tissues in the child.

The many **myths** as to the SPECIAL INFLUENCES OF CERTAIN KINDS OF FOOD are thus seen to have no foundation whatever, since all are reduced to their simple and common components before they can reach the placenta or pass through into the fetal circulation. Meat is no better for building muscle than milk, since the proteins of both are delivered to the fetal tissues in the form of their digestion products, amino acids, which must be recombined in new ways to make muscle proteins. It should also be apparent that there cannot possibly be a chance of influencing the growth or development of the child by the THOUGHTS or EMOTIONS of the mother,



Fig. 84. A disaster in reproduction caused by feeding a ration made from wheat straw, wheat meal and wheat gluten, with common salt. The cow was shaggy-coated, slow and sleepy in movement, and had a tendency to drag her hind feet. The calf was born prematurely and died. (From Research Bulletin 17, University of Wisconsin Agricultural Experiment Station.)



Fig. 85. When the ration fed to the cow shown in Fig. 84 was supplemented with bone meal 2 per cent, common salt 1 per cent, and raw cod liver oil 2 per cent, its deficiencies were fully corrected. This cow was in excellent condition and produced twins weighing 124 pounds. (Courtesy of Doctors Hart and Steenbock.)

since there is **no nervous connection** between the two organisms. FEAR, WORRY, and other emotions which make for POOR DIGESTION in the mother, and hence exert an unfavorable influence on her nutritive condition, may thus affect the nutrition of the child **indirectly**, but at other times nature may be able to produce a strong, healthy child IN SPITE OF POOR GENERAL CONDITIONS in the mother.

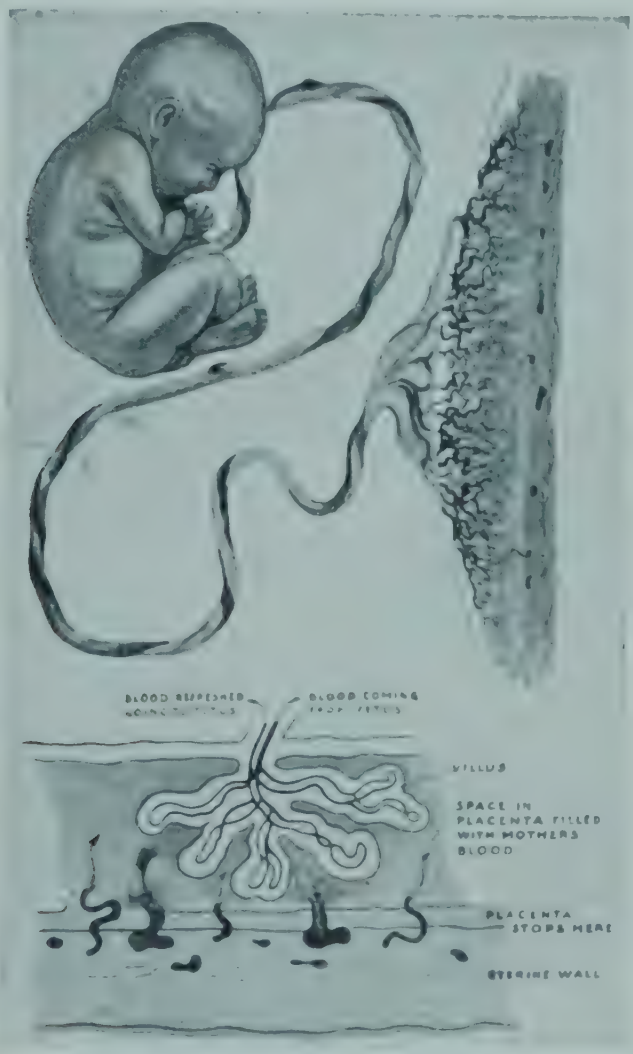


Fig. 86. Diagrams to show the relations to the maternal and fetal circulations. (From DeLee, "Obstetrics for Nurses.")

The BONES and TEETH of the mother constitute **reservoirs** of CALCIUM and PHOSPHORUS, which may be drawn upon for bone-building materials for the child's body, if the food of the mother is lacking in these substances. Whatever stores of the fat-soluble VITAMINS she may have in her tissues may also be drawn upon by the child in case of need. It should be remembered that water-soluble vitamins are not stored to any appreciable extent. Naturally, every effort should be made that the **current food in-**

take of the mother will be **adequate** so that the building materials for the child will come from this source rather than from DEPLETION OF THE TISSUES in the mother's body.

DIFFERENT STAGES OF PREGNANCY AND THEIR SPECIAL NEEDS

It may be dangerous or confusing to make statements about the period of pregnancy as a unit, for the **nutritive needs** to be supplied and special **dangers** to be guarded against are **different in the earlier and later stages of pregnancy,** as indicated in the following brief résumé:

First to Fourth Months Inclusive. During the EARLY part of pregnancy the materials needed for the growth of the fetus are so small in amount that any **increased need for fuel and building materials** is practically **negligible**—in other words the pregnant woman should eat during this period just what any woman should eat who would preserve her health and vitality. On the other hand, a great many women are apt to experience NAUSEA and DIGESTIVE DISTURBANCES in the early part of pregnancy, so that special care should be taken to AVOID OVERTAXING the digestive tract with unneeded food or foods difficult to digest, as well as to guard against such factors as fatigue, excitement, worry and constipation, which have an unfavorable influence on digestion. Hence, the diet should be limited to MODERATE amounts of simple, EASILY DIGESTED FOODS, which may often be better utilized if taken in small amounts at SHORTER INTERVALS than usual. A few crackers, a cup of rather strong tea or black coffee taken before getting up in the morning may relieve the nausea apt to occur at this time ("morning sickness"). Simple lunches (such as crackers, gruel, milk drinks, or fruit juice) taken in the middle of the morning or afternoon, or before retiring may also help.

The **nausea** is due not to any difficulty in the alimentary tract itself but to readjustments necessary in establishing the connection between the maternal and fetal circulations through the placenta (see p. 483). As soon as this connection is well established the nausea should disappear and the mother's appetite and digestion should improve. If nausea is severe enough to produce much VOMITING, a state of semistarvation with resultant ACIDOSIS may develop. In such cases it is essential that the diet furnish an excess of BASE-FORMING ELEMENTS, for which purpose fruits and vegetables are most helpful. Plenty of CARBOHYDRATE in the diet, especially such easily utilized carbohydrates as the sugars (sugars in fruit juices, milk sugar or malt sugar are best) may also relieve the vomiting and acidosis by doing away with the existing state of semistarvation.

Fifth, Sixth and Seventh Months. This period, comprising the MIDDLE portion of pregnancy, sees a moderate rate of growth on the part of the fetus, which calls for a **slight increase of energy** and of ALL the **materials for tissue building** in the diet of the mother. The old adage that "she who is nourishing two must eat for two" is misleading when taken to mean (as it often is) as much as two adults would need. The CALORIES taken need not exceed a 10 PER CENT INCREASE over what the nonpregnant woman would require, and the actual amount of building materials needed by the fetus from day to day is still comparatively small. In general, pregnant women are more likely to overeat in this period than to undereat.

Eighth and Ninth Months. Probably at least half of the total gain in weight of the fetus will occur during the last eight to ten weeks of pregnancy. This then is the **period of rapid fetal growth,** when considerable extra energy and tissue-building materials must be furnished in the food unless either the mother or the child (or both) is to suffer. Even in late pregnancy, however, the need for **extra fuel foods** will not exceed by more than one-fifth (20 PER CENT) the amount required by the woman when not pregnant, *i. e.*, a sedentary woman who ordinarily needs about 2000 calories will require 400 extra calories in late pregnancy, or a total of 2400 calories. This should be enough to provide for a gain of about 20 lbs. in weight, which will cover the weight of the baby, placenta, water, membranes, etc., as well as a slight gain in the mother's own weight.

Overeating or undereating as to calories is thought now not to have so much influence upon the weight of the child and difficulties of delivery as formerly supposed. Many physicians believe that it requires such extreme curtailment of food to affect the size of the fetus that nutritional deficiencies in the mother are likely to result. Ebbs, Tisdall and Scott[1] found that the average birth weight of babies was about the same in a group of mothers who were given extra food in the latter months of pregnancy as in a control group who were left on a poor diet much lower in calories. Some authorities[2] state the normal and desirable weight gain during the 9 months of pregnancy to be 20–25 lbs. spaced to gain about 5, 10 and 10 lbs. in three successive 3 month periods.

It is very important, however, that the food during this period should be **unusually rich** in all the **elements needed by the growing child,** so that its best development may not be limited by any lack of building material nor will there be a need for the child to draw on the maternal tissues for

[1] Ebbs, J. H., Tisdall, F. F., and Scott, W. A., J. Nutrition, v. 22, p. 515, 1941.

[2] Conn, L. C., Vant, J. R., and Malone, M. M., Surg. Gynec. & Obst., v. 62, p. 377, 1936.

the materials for its growth. The EXTRA CALORIES needed, therefore, SHOULD BE TAKEN IN THE FORM OF FOODS WHICH ALSO PROVIDE HIGH QUALITY PROTEINS, MINERAL ELEMENTS, AND VITAMINS.

There has also been revision of ideas as to the desirable quantity of protein in the diet and more stress as to the quality of proteins provided, since a goodly supply of all the essential amino acids is needed for fetal growth. Some doctors still feel that too high protein intake means greater dangers of kidney damage and eclampsia (a toxic state and convulsive seizures in late pregnancy); others believe that low protein intake may be associated with anemia and nutritional edema (bloating due to extra water held in tissues). The consensus of opinion, however, seems to be that a reasonably high protein intake is needed and does no harm, also that it favors milk se-

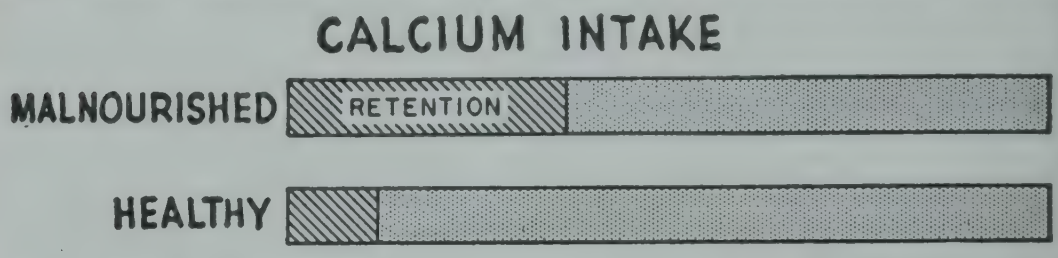


Fig. 87. Diagram showing greater retention of calcium to build up body stores of this mineral element in a pregnant woman whose previous diet had been unsatisfactory. The malnourished pregnant woman retained in her body a higher percentage of the calcium intake per kilogram of body weight than did the healthy pregnant woman. (Macy, I. G., and Williams, H. H., Hidden Hunger, Jaques Cattell Press, Lancaster, Pa.)

cretion in the later period after birth of the infant. At least half of the protein should be of animal origin, such as that provided by meat, eggs and milk.

A **surplus** of certain **minerals** and **vitamins** in the mother's diet will benefit the child, in that they can be **stored** in the liver or tissues of the fetus. The child will then be born with reserve stores of these substances that serve as a protection against future needs. If the mother's diet is rich in IRON during pregnancy, the child will be born with a liver well stored with iron, often a sufficient reserve to last through the months during which it will be fed chiefly on milk, a food of low iron content. The teeth of the child are formed and in large part calcified during the latter half of the period of prenatal life and the first months after birth. Extra CALCIUM for the mother during pregnancy and lactation will go far toward insuring teeth of good quality and well-calcified bones in the child. Usually extra vitamin D, to assist in utilization of calcium and phosphorus, is advisable. It may be taken in fish liver oil or some concentrate in capsules, as pre-

ferred. The FAT-SOLUBLE VITAMINS may be stored in the liver, and reserve stores of these vitamins in the child's body will help to promote growth and to protect against infection.

The best evidence we have that the nutritive condition of the mother during pregnancy frequently does influence, not only her own health but the well-being of her child, comes from recent investigations at the medical schools of Toronto and Harvard Universities.[3] In each case, pregnant

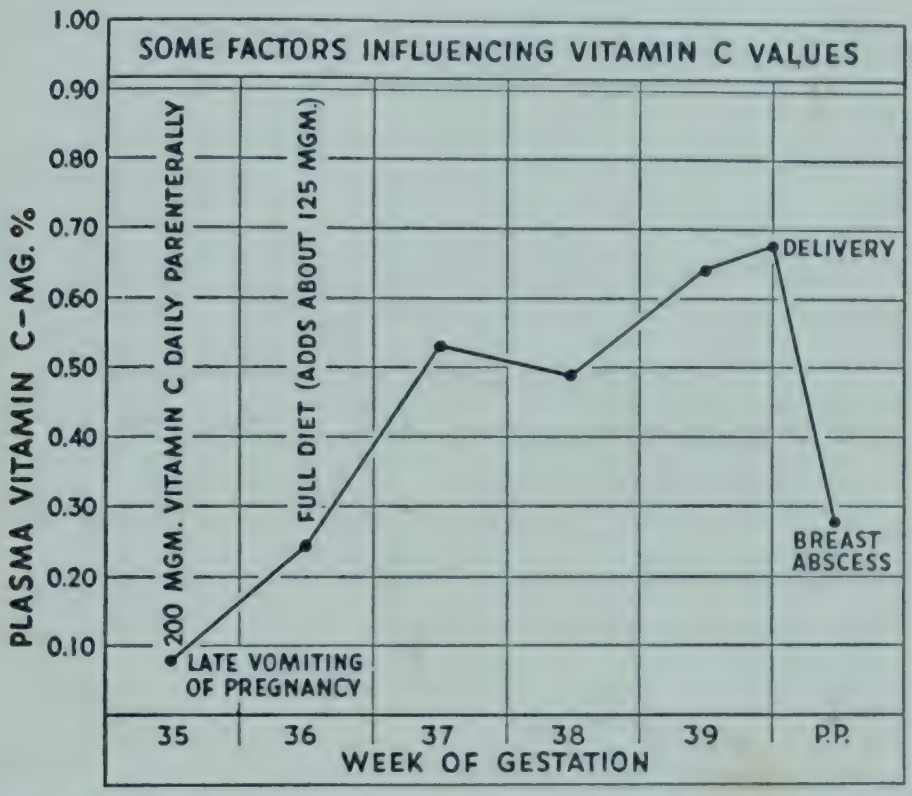


Fig. 88. Curve showing need for extra vitamin C in a pregnant woman. Low vitamin C level in blood plasma, induced by vomiting and lack of food, was raised by fairly large doses of this vitamin, but fell off again when infection (breast abscess) increased the need for vitamin C. (Nutritional and Vitamin Therapy in General Practice, 3d Ed., Edgar S. Gordon: Yearbook Publishing Corp.)

women from low income groups were studied during the later months of pregnancy, and for some time after birth of the children. Some whose diet was found to be poor received supplementary food, while others were left on the poor diet as controls. Those who received good diets had better health, both before and after delivery, fewer complications at delivery, also fewer miscarriages, stillbirths or premature deliveries, than the mothers who were on poor diets during pregnancy. Most of the babies whose phys-

[3] Ref. to Ebbs, *et al.* in footnote 1; Burke, B. S., *et al.*, J. Nutrition, v. 26, p. 569, Am. J. Obst. & Gynec., v. 46, p. 38, and J. Pediatrics, v. 23, p. 506, 1943.

ical condition was rated as superior at birth were born to mothers who had better than fair diets; babies born of mothers who had poor diets had more illnesses during the first six months of life.

LACTATION

Nutritive Requirements of Nursing Mothers. In lactation, as well as in pregnancy, the **requirement** for ALL the various NUTRITIVE FACTORS is **increased.** In pregnancy the increased demands are for the growth of the fetus WITHIN the mother's body; in lactation, the extra energy, protein, minerals and vitamins go into the MILK formed for the nourishment of the child. Thus either directly or indirectly the extra requirements of the mother are caused by the necessity of providing the material for the child's growth through her own body.

The two periods differ chiefly in that the **extra demands** on the maternal organism are **greater in lactation,** on account of the increased size and growth of the child over that in prenatal life. Also diet probably exerts a more direct and important influence in lactation, since the secretion of milk may readily be much diminished or entirely suppressed as a result of inadequate diet, while in pregnancy the growth of the child may go on satisfactorily even when the diet is inadequate, by drawing on the mother's tissues for the necessary building materials.

Foods which are taken to supply the increased energy needs should be, in so far as possible, also bearers of minerals and vitamins. Milk is the best source of high quality protein, calcium and phosphorus, as well as of several vitamins. Fruit juices supply fluid and vitamin C. Sunshine or cod liver oil are needed as sources of vitamin D.

Why Human Milk Is Better than Cow's Milk for Babies. In general, the **milk of an animal** is of a **composition best suited** to the normal rate of **growth of that species.** The more rapid the rate of growth the more concentrated the milk needs to be in tissue-building materials. As the infant grows much more slowly than the calf (calf doubles its birth weight in forty-seven days, infant in about one hundred and fifty days), cow's milk has to be stronger, or more concentrated in certain building materials, than human milk, and the baby's sensitive digestive tract is better able to handle the more dilute nutriment. Thus, **cow's milk** has about TWICE AS MUCH PROTEIN and FOUR TIMES AS MUCH CALCIUM salts as human milk; while **human milk** contains MORE SUGAR, and, in spite of its lower total protein content, furnishes about TWICE AS MUCH LACTALBUMIN, the special protein which is the most efficient one known for promoting growth because of the nature of the amino acids it supplies (see p. 151).

Moreover, the curd which human milk forms in the stomach is much finer and more flocculent than that formed by raw cow's milk (see Fig. 10, p. 71), and hence is better adapted to the infant's powers of digestion. Usually cow's milk has to be diluted one-half to one-third in order not to overtax the limited digestive powers of YOUNG infants, and under these conditions it may be difficult for the child to take a large enough volume to get the nourishment it needs. Cow's milk which has been heated (such as boiled, evaporated or dried milks) gives a finer curd than raw milk, so that it is more easily digested and can be taken at higher concentrations. Cow's milk which has been artificially soured, *i. e.*, lactic acid milk, can often be given undiluted in the same amounts as breast milk. With human milk, however, there is no danger of feeding a wrong formula which disagrees with the baby and upsets digestion, so that the infant can take with safety any amount necessary to meet its needs.

In addition to all the above reasons, the baby which is breast-fed has a better chance of surviving infancy and of being healthy later on, because of the great reduction of the dangers of infection. When the milk is thus given direct from producer to consumer, all the manifold dangers of contamination with harmful bacteria, and of undue growth of bacteria while being stored, are ruled out. Even bacteria which are not disease-producing organisms may cause diarrhea and grave digestive disturbances in infants, if present in the milk in too large numbers. When cow's milk is used for babies, it is best pasteurized or boiled in order to rule out bacterial contamination as far as possible, and great care is necessary to have all utensils sterilized and to keep milk thoroughly chilled to prevent the strains of bacteria, always present in milk to some extent, from multiplying unduly. All of these dangers and difficulties are done away with when the baby is nursed by the mother.

Factors Affecting Milk Secretion. Every child has a right to the improved chances of life and health which maternal feeding will give him, and a far larger number of women could nurse their infants, if they would follow a diet and habits of life such as favor the production of milk, both during pregnancy and in the months immediately following the child's birth. Many mothers speak of not being able to nurse their babies as if this were a phenomenon governed by Fate instead of being chiefly their own responsibility. "Successful nursing demands a quiet, contented life, in which food is intelligently chosen and exercise, fresh air, and mental diversion are provided."[4] There is more truth than fiction in the old advertising slogan, as to milk "produced by contented cows." EXCITEMENT, FATIGUE, CONSTIPA-

[4] Rose, M. S., "Feeding the Family," Macmillan, 4th ed., 1940, p. 164.

TION and DIGESTIVE DISTURBANCES all react unfavorably on milk production and must be guarded against.

There is no doubt but that the character of the **diet** during pregnancy and lactation is of great importance and may affect lactation either favorably or adversely. The most important dietary factors for stimulating a good flow of milk are liberal intake of FUEL FOODS, plenty of HIGH QUALITY PROTEINS, and an abundance of VITAMINS. Plenty of FLUIDS should also be taken. A shortage of any of these essentials is likely to be reflected almost immediately in decreased **quantity** of milk produced, without affecting quality of milk so much. Milk is, of course, rich in calcium and phosphorus, but taking too little of these mineral elements results in "negative

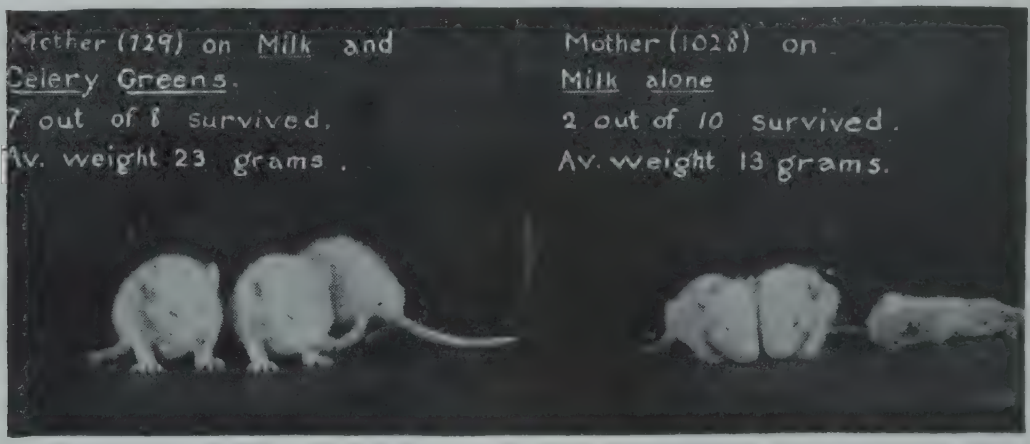


Fig. 89. Influence of diet on lactation. Lactation was evidently improved by the presence of green stuffs (celery greens) in the diet (see left-hand picture above), since a larger number of offspring survived and the average weight of the offspring was greater than in the right-hand illustration. The vitamins in the celery greens stimulated better lactation. (From Cooper, Barber and Mitchell, "Nutrition in Health and Disease for Nurses," J. B. Lippincott Co., Publishers.)

balance" or loss of these elements from the mother's body, rather than in the formation of less milk or any deficiency of these mineral elements in the milk.

A shortage of **vitamins** in the mother's diet, however, is likely to mean a low content of vitamins in her milk. This is particularly true in respect to the water-soluble vitamins (C, and those of the B-complex) which cannot be stored to any appreciable extent. Infantile beriberi may occur in children that nurse from mothers whose intake of vitamin B_1 has been markedly low. Conversely, children of mothers who have received plentiful supplies of vitamin D are to some extent protected against rickets.[5] Since fat-soluble

[5] However, it requires such a high intake of vitamin D for the mother to get enough vitamin D into the milk as to assure adequate protection for the child, that we take no chances but give cod liver oil or other rich source of vitamin D even to breast-fed babies.

vitamins can be stored in the body, the mother may draw on her own reserves of these vitamins, and a dietary shortage of the fat-soluble vitamins is less quickly reflected in low content of these vitamins in the milk.

Hence we see that it is important that the lactating woman should have reserves of calcium, phosphorus and fat-soluble vitamins built up during pregnancy. Too often women are under-nourished in pregnancy, or even earlier, so that they enter the period of lactation with little reserves to meet its extra demands. To insure good milk flow dietary conditions should be of the most favorable character throughout pregnancy.

Even when the milk flow is insufficient to meet the full needs of the child, whatever is secreted should be used and the child put to the breast, as the mechanical stimulus of nursing may result in gradually increasing milk secretion. Manipulation of the breasts or withdrawing milk with a breast pump (when the child is too weak to nurse) may have similar stimulating effects on milk flow.

Modifying Cow's Milk for Infant Feeding. Even with the best intentions and care, cow's milk may have to be resorted to either to supplement a scanty flow of breast milk or as the mainstay of an artificial diet. Artificial feeding of infants has been so highly developed as a science that it usually can be very successfully carried out with advice of a pediatrician or child health clinic. Pasteurized, boiled, or evaporated milk is best used. It is made more easily digestible, and the high concentration of protein and mineral salts is reduced by diluting it, while to increase its fuel value some form of sugar is added (usually corn sirup, dextri-maltose, or cane sugar). The amount of dilution required depends on the digestive powers of the infant. As the baby grows older, it becomes able to take undiluted cow's milk. Breast-fed infants often get supplementary feedings with cow's milk, and at eight to twelve months of age are able to be weaned and to take cow's milk directly from a cup. Weaning from the breast to a bottled formula may be accomplished much earlier if circumstances require. Both breast-fed babies and those fed a cow's milk formula should have the diet supplemented by orange juice, cod liver oil, well-cooked cereals, egg yolk, sieved vegetables and strained fruits. These supplementary foods are introduced gradually, most of them between 2-6 months, in order to give more calories, minerals and vitamins, and also to accustom the baby to a wider range of foods.

RECOMMENDATIONS AS TO DIET

The allowances for the various nutritive factors, recommended by the Food and Nutrition Board of the National Research Council (1948), for

pregnant women and nursing mothers are given in Table XXXIII, along with those for a normal sedentary woman of average weight.

TABLE XXXIII. DIETARY ALLOWANCES IN PREGNANCY AND LACTATION

	Calories	Protein	Calcium	Iron	Vitamin A	Thiamine	Riboflavin	Niacin	Ascorbic Acid	Vitamin D
		gm.	gm.	mg.	I.U.	mg.	mg.	mg.	mg.	I.U.
Woman:										
Normal, sedentary	2,000	60	1.0	12	5,000	1.0	1.5	10	70	?
Pregnancy (latter half)	2,400	85	1.5	15	6,000	1.5	2.5	15	100	400
Lactation	3,000	100	2.0	15	8,000	1.5	3.0	15	150	400

In Pregnancy. The nutritive needs are best met by a simple, wholesome diet the basis of which is MILK, EGGS, MEAT, WHOLE GRAINS, FRUITS AND VEGETABLES. In general, the more fruits and vegetables taken the better, since these foods not only help to insure the SURPLUS of VITAMINS and MINERAL ELEMENTS which is so very advantageous, but make the diet BULKY and LAXATIVE so that constipation may be prevented. Whole grain foods have the same effects as fruits and vegetables, in contrast to the highly milled grains which are low-residue foods almost devoid of minerals and vitamins (unless they have been enriched by addition of some of these essentials).

Milk is the food PAR EXCELLENCE for pregnancy and 1 qt. of it should be taken daily in some form without fail during this period. Much of it may be incorporated in cooked foods, if preferred. It is our best carrier of the high quality proteins, mineral elements (especially calcium) and vitamins, which are vital for the growth of the child, and is unique in furnishing ALL of these needed nutritive factors in a single food in such well-balanced amounts. Egg yolk is also relatively rich in vitamins and mineral elements, especially iron, which is almost the only nutritive essential that is provided in but small amounts by milk; at least one egg a day is a good rule. Meat may be taken once a day, with cheese, nuts, or legumes occasionally, if tolerated, and liver should be taken once a week.

Cereal foods are easily digested and useful for providing the needed fuel. Some of the increased energy need can be met by adding small amounts of fat to the diet, though fats should be taken in the form of cream, butter, bacon or salad oil, rather than incorporated in fried foods, fat meats, gravies and pastries.

Assuming that the nonpregnant woman has been taking a diet that included 1 pt. of milk and 1 egg daily, moderate amounts of meat and cereal foods, and a LIBERAL allowance of fruits and vegetables, the extra needs of

the later months of pregnancy could be met to excellent advantage simply by ADDING TO THE ORDINARY DIET 1 PT. OF MILK, 1 EGG, 1 TABLESPOONFUL OF BUTTER AND ONE LARGE SERVING OF SOME GREEN VEGETABLE. This additional food would supply over 500 calories and at the same time furnish considerable amounts of the high quality proteins, mineral salts and vitamins for which there is special need at this time. Probably most women would also do well to alter their ordinary diet so as to take more fruits and vegetables than in the period prior to pregnancy. In the earlier part of pregnancy, some advise a woman to cut down a little on high calorie foods and take more calories in fruits and vegetables; then when extra fuel is needed in the later months of pregnancy, she may obtain this by adding some foods of higher fuel value. It should be remembered that the energy needs vary with weight and especially with degree of activity, so that the calorie allowances for normal and pregnant women in the table on p. 494 apply only to women of average weight (123 lbs.) and sedentary habits. Most women are not muscularly active during late pregnancy but, if they are, the energy need may range up to 3,000 calories per day.

The less elaborately cooked the food is the better, and some raw foods should be taken daily (fruits and salads). If digestion is upset or there is difficulty in taking enough food, the regular meals may be reduced in size and extra nourishment given between meals in the form of easily digested foods, such as milk, eggnog, malted milk, cereal gruels, crackers, fruit or fruit juice. Meals may easily be made to fit into the family schedule, if foods for the family are wisely chosen, *i. e.*, planned to be of high nutritive value and simply cooked.

The **habits of living** should be carefully looked to, since good nutrition is impossible, whatever the food supply, in the presence of such unfavorable factors as excitement, worry, overfatigue, irregular meal times, bolting food, insufficient sleep, and constipation. A moderate amount of EXERCISE in the fresh air and sunlight is also essential, while taking COD LIVER OIL (or some substitute) in the latter part of pregnancy to supply extra amounts of the D vitamin, in which none of our foods is rich, is a distinct advantage both to the infant and mother.

For Nursing Mothers. Few persons realize how markedly lactation can be influenced by diet. It must be appreciated, however, that the favorable dietary conditions SHOULD BEGIN DURING PREGNANCY in order to produce their proper effect in stimulating milk flow immediately after delivery.

THE MOST IMPORTANT DIETARY FACTORS IN PRODUCING SATISFACTORY LACTATION ARE A LIBERAL INTAKE OF FLUIDS AND FUEL FOODS, PLENTY OF HIGH QUALITY PROTEINS, MINERAL SALTS AND VITAMINS. Most nursing mothers are apt to stuff themselves and to take a liberal amount of milk in

the effort to promote milk secretion, thus providing more than the needed calories and plenty of good protein, but do not realize the desirability of taking, DURING PREGNANCY, large amounts of fruits and green or yellow vegetables with some additional vitamins in concentrated form (extract of halibut or cod liver oil, orange or tomato juice, cereals with wheat germ added, or dried yeast tablets). It may be necessary to keep up these practices during the early part of the nursing period, although frequently when lactation has once become well established, the mechanical effect of the emptying of the breasts through nursing, together with a liberal calorie and protein intake and a moderately abundant supply of vitamins, is sufficient to stimulate the continued secretion of milk. Plenty of natural, unrefined foods should be included in the diet to supply possible as yet unknown vitamins which may be needed for lactation.

It must also be borne in mind that the mammary glands are extremely sensitive to nervous influences, so that anything which upsets the nervous equilibrium tends to react toward the suppression of milk secretion. Factors other than diet, which influence milk secretion favorably or adversely, were enumerated on p. 491.

Recommendations for the diet in the nursing period are almost identical with those given above for pregnancy, except that the need for almost all nutritive essentials is greater during lactation, especially as the infant grows and takes larger quantities of milk. The QUALITY of the diet required remains essentially the same—a diet fairly high in calories and containing liberal amounts of milk, eggs, fruits and vegetables to furnish the extra protein, mineral salts and vitamins needed. Probably some EXTRA QUANTITIES OF THE MORE CONCENTRATED FUEL FOODS (cereal products, potatoes, cream, butter or margarine) will need to be added in order to furnish the large amount of energy that is required without too great bulk of foods. Only the more simple, EASILY DIGESTED foods should be used, if the alimentary tract is not to be overburdened by the quantity of food taken.

The average woman will require about **2800–3000 calories.** In general, we may say that a woman of sedentary habits will need to consume about as much food when nursing an infant as if she were doing hard muscular work, while a working woman will require approximately as many calories during this period as a man who is moderately active muscularly. The high allowances for protein, calcium, iron, and the various vitamins during lactation were given in Table XXXIII on p. 494.

Milk is the best food both for promoting milk secretion and for protecting the mother's own tissues from any possible drain, and at least 1 qt. of milk should be taken daily, preferably $1\frac{1}{2}$ quarts. It is a good thing to take **supplementary nourishment** just before nursing the baby in the

middle of the morning and afternoon, and at bedtime. Some milk or cereal mixture is best, *e. g.*, hot milk, malted milk, buttermilk, cocoa, eggnog, Graham crackers, oatmeal gruel with cream. Milk soups, cream sauces, and custards should appear frequently in the menu and in addition milk should be used as a beverage with meals, if possible. It is essential to have a plentiful intake of **fluids** (1–2 qts. from all sources) to provide the water in the milk secreted in addition to that needed by the mother; fruit juices and tomato juice are useful to give added fluids, as well as vitamins.

While it is essential to have enough food to meet the increased requirements at this time, **overeating** will only upset digestion or result in an undesirable weight increase for the mother, without improving the quality of the milk or increasing the amount secreted. An excessive intake of vitamins will not increase the vitamin content of the milk above a certain level, though a low vitamin intake means vitamin-poor milk. High intake of mineral elements, especially calcium and phosphorus, is needed not only to provide these elements in the milk but to protect the bones and teeth of the mother.

QUESTIONS AND PROBLEMS

1. Discuss the special problems and calorie needs of the different periods of pregnancy. Do the needs for protein, mineral elements, and vitamins differ in early and late pregnancy, and if so, how?

2. By what selection of food groups could the higher calorie need of the latter half of pregnancy be satisfied and at the same time a diet rich in good quality protein, mineral elements and vitamins be provided? What food groups should be prominent in the diet during pregnancy?

3. What would be the dangers, if any, resulting from taking a diet during pregnancy that did not meet the requirement for energy, for protein, for calcium, for iron, for vitamin A, for vitamin D, for vitamin K, for vitamin B_1 (thiamine)?

4. Compare the allowances for each of the nutritive factors in late pregnancy with those for a woman who is nursing a baby (see table on p. 494). In what respects do the requirements in lactation differ from those in pregnancy, and why? Why are more calories, protein, calcium, phosphorus, and vitamins needed than are passed on to the baby in the mother's milk? Why do so many women become overweight when nursing a child? What factors in the diet, if taken in plentiful amounts, favor milk secretion? What nervous and environmental factors tend to suppress milk secretion?

5. Plan a day's meals for a woman in the last two months of pregnancy. Calculate the calories and protein in this diet, and compare with the allowances on p. 494 to see whether the diet is adequate in these respects. Can

you make any suggestions as to how it might be altered to provide more liberal intake of mineral elements and vitamins? Does the woman need some vitamin D supplement, and why?

6. Plan a day's diet for a nursing mother and calculate the amount of calcium and vitamin A supplied to see whether they are adequate. If the diet needs to be improved in these respects, what changes would you suggest?

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CHAPTER 28

DIET AFTER FORTY

DANGERS OF MIDDLE AGE. The high mortality between the ages of forty and sixty, especially in the United States among men, would indicate either an increasing strain at this period as a result of the growing demands of business and social life, or a lessening ability of the organs to meet their functions—probably both. Deaths in middle life are usually due to the giving out of various vital parts of the body, when subjected to strain. Nervous collapse, high blood pressure, hardening of the arteries, apoplexy, heart failure and kidney disease are some of the types of functional disease that are likely to set in at this time.

To meet this period successfully certain **precautions** need to be observed. Of course the best insurance against wearing out in middle life is taking an optimum diet and following good habits of hygiene from childhood, thus building a strong body and keeping it in good condition. If this has been done, all that is needed is to keep up this régime and to provide for lightening the strain of living in the following ways:

(1) CUT DOWN ON THE **amount** OF FOOD EATEN sufficiently to combat the tendency to put on weight.

(2) Be MODERATE in the use of FATS (especially animal fats), PROTEIN-RICH FOODS, SALT AND CONDIMENTS; take PLENTY of WATER.

(3) Get plenty of fresh air and exercise, but **avoid strenuous exertions** which overfatigue and place undue strain on the heart.[1]

(4) Take more RECREATION and REST.

(5) Cultivate mental hygiene (courage, poise, self-control); **avoid nervous strain** (worry, irritation, excessive excitement or exhausting emotions).

Each of the above recommendations for easing up in middle life would

[1] Track sports, baseball, football, boxing, and competitive rowing or golf should be ruled out. Walking, swimming, hunting and fishing, mild rowing or golf, billiards or pool are forms of exercise suited to the later years of life. Tennis, badminton, etc. are games that some persons keep up well into middle age but usually they play a more liesurely game than young people. Keeping up exercise consistently and in moderation is the important thing.

repay discussion but we have space here only to point out their effect in **sparing the somewhat weakened organism** from undue strain. (1) and (2) are designed to PREVENT OVERWEIGHT (for the numerous disadvantages of excess weight see pp. 513–514), to lighten the work of the ALIMENTARY TRACT, LIVER and KIDNEYS, and to favor EXCRETION; (3) guards against making too great demands on the CIRCULATORY SYSTEM; while (3), (4) and (5) are all useful in providing rest for the NERVOUS SYSTEM and for the whole body.

Prevention of Senility. The bodily condition known as "old age" or senility, while it almost invariably develops sooner or later, is not the inevitable result of living a certain number of years, and may be long postponed, or even prevented entirely, by the right dietary régime and manner of living. On the other hand, a poor diet or the wrong mode of living may bring on premature senility. Some people are "older" in body at forty than others at eighty.

Senility is not the necessary result of wear and tear, but rather of **improper use of the body** and of habitually taking a **diet** which does not maintain the tissues at their highest degree of vitality. Those who succeed in retaining their youthful vigor in the later years of life are usually not inactive people but, on the contrary, are those who are active mentally and moderately active physically. The most noticeable trait which they have in common, is adherence to a SIMPLE DIET and a REGULAR LIFE, FREE FROM **immoderation** in all respects.

Various persons have proposed certain measures as an aid to warding off senility and **prolonging life.** One of the earliest and most classic examples is Cornaro, an Italian nobleman, who was so broken in health at forty that his physicians told him he must choose between an early death or radical reform in his habits of life. Due to following a rather sparse and simple diet and to leading a more regular life, he regained his health, lived to be one hundred years old, and wrote a treatise upon his system of diet when over eighty. Modern nutritionists stress the possibility not only of increasing the number of years lived but of lengthening the productive period known as the "prime of life."

The experiments of Sherman and his co-workers[2] in feeding rats through the whole life span, and even through successive generations, on diets that were "adequate" or that were "optimum" as to certain nutritive factors are

[2] Sherman, H. C., *et al.*, Effect of Increasing the Calcium Intake, J. Nutrition, v. 10, p. 363, 1935; Nutritional Well-Being and Length of Life as Influenced by Different Enrichments of an Already Adequate Diet, J. Nutrition, v. 14, p. 609, 1937; Responses to Different Levels of Nutrition Intake of Riboflavin, Proc. Natl. Acad. Sci., v. 25, p. 420, 1939; Vitamin A in Relation to Aging and to Length of Life, Proc. Natl. Acad. Sci., v. 31, p. 107, 1945.

most suggestive. Those on the diet considered adequate appeared healthy and lived a normal length of life; but rats that received much higher levels of calcium, vitamin A or riboflavin lived considerably longer and retained greater vitality almost until their death—the symptoms of old age were postponed. Riboflavin (vitamin B_2) has a striking influence in preventing signs of senility. If a young rat is deprived of this vitamin for several months it looks and acts aged, but if then given liberal amounts of riboflavin, it becomes supple, healthy and young looking in a short time. We know less as yet about what are "optimum" amounts of the other nutritive factors, but the consensus of opinion is that much could be done to avert senility by proper diet. Mackay and Maynard found that rats which matured more slowly, because they received a lower caloric intake, lived longer than those that were liberally fed. Recently published work of Elvehjem[3] and co-workers tends to confirm the theory that restriction of calories may lead to longer life span, at least in rats.

We may sum up the advice on how to prevent the development of senility and prolong the active period of life, as follows:

Favorable Factors	Unfavorable Factors
1. Diet of simple, easily, digested foods which supplies: sufficient calories and protein; plentiful amounts of all essential: amino acids, mineral elements, vitamins	1. Diet (a) which supplies an insufficient amount of any of the necessary nutritive factors. (b) which involves a "luxury consumption" of total food, of animal fats or protein-rich foods, of rich foods, condiments or sweets.
2. Simple, regular life	2. Irregular life, with improper proportion between work, recreation and rest.
3. Avoidance of unfavorable factors	3. Excesses which place undue strain upon weakened organs or tissues.
	4. Unfavorable mental or emotional conditions.
	5. Constipation.
	6. Overweight.

Decreased Body Needs. From the discussion in the preceding section as to the dangers of lowered vitality from too low intake of nutritive essentials and the benefits that may accrue from high intake of certain min-

[3] Riesen, W. H., Herbst, E. J., Walliker, C., and Elvehjem, C. A., Am. J. Physiol., v. 148, p. 614, 1947.

erals and vitamins in postponing senility and lengthening life, it should be evident that the idea of a sparse and abstemious diet for later life has gone out of style, and for good reasons. The same nutritive essentials (fuel, protein, mineral salts and vitamins) are required in adequate quantities to nourish the body "from the cradle to the grave," and an insufficiency of any of them will do harm at any age.

However, it is true that at least some nutritive factors are needed in smaller quantities in the latter part of life (especially after seventy) than in the more active adult years. There is no further need of tissue-building materials for growth, and the amount of these substances needed for tissue maintenance or repair is usually less. The need for fuel foods is reduced slightly in later years and it is generally held that the protein intake should be reduced by about the same amount as the caloric intake. Too little protein may be as bad or worse than too much and nothing said here should be taken to minimize the need for a certain amount of high quality protein to provide for tissue rebuilding which goes on to some extent throughout life. The principal curtailment should be in the intake of foods that supply only or chiefly calories.

The **calorie requirement** is materially **reduced** for two reasons—

(1) less energy is used in MUSCULAR ACTIVITY, and

(2) the BASAL METABOLISM is lowered.

The inner fires of metabolism actually burn more slowly in old age. It is estimated that the energy used by the body processes when at rest (basal metabolism) is about 10 per cent less than formerly between sixty and seventy, 20 per cent less from seventy to ninety, and about 25 per cent less after ninety years of age. Thus a man of average weight and in middle life would require about 1840 calories per day for maintenance when in bed; the same man, without any muscular activity, would require for maintenance alone at sixty to seventy years about 1650 C., and at seventy to eighty years 1475 C. In earlier life the muscular activity might be sufficient to raise the energy requirement 500 to 2000 calories, *i. e.*, to somewhere between 2300 and 4000 calories, depending upon the amount of muscular work done; few men in their seventies would do enough muscular work to raise their total energy requirement to more than 1800–2000 calories. Small, aged women may have surprisingly low calorie needs.

Hence, it will be apparent that the TOTAL AMOUNT OF FOOD, especially foods of high fuel value, should be SOMEWHAT CURTAILED AFTER reaching SIXTY years (slightly so even at forty to sixty years of age), and CONSIDERABLY REDUCED AFTER SEVENTY. A keen appetite, a fondness for fatty or starchy foods and sweets, the continuance of eating habits acquired in the

more active years, or the increased money spent for food in the more prosperous years of late middle life, may readily result in the consumption by an elderly person of more fuel foods than are required for his diminished body needs.

The caloric reduction should be accomplished chiefly by cutting down on foods that have high fuel value but contribute little besides energy (sweets, highly milled cereals and fats); a high proportion of the calories taken should come from foods that are carriers of high quality protein, mineral elements and vitamins. Otherwise the restriction of calories will mean restriction of protein, minerals and vitamins that may do harm. The "tea and toast" diet of little old ladies is distinctly not to be recommended. Old people may easily become malnourished by taking too little food or a diet lacking in essential nutritive factors. Appetite, gastric acidity, perhaps absorptive powers and storage of vitamins and minerals may begin to fail with age. The brittle bones of many old persons are evidence that not enough calcium has been available for upkeep of bones. Thus everything points to the fact that the diet should be restricted as to little else but calories, and it may need more than ever to be high in some or most of the other nutritive factors.

Decreased Functional Abilities. In the later years of life the ability of the body to handle an excess of food is diminished. First, the LOSS OF TEETH frequently results in inability to masticate hard or coarse foods. Inadequately chewed foods may place an added strain on digestion, or the omission of all coarse foods from the diet may lead to constipation. The movements of the alimentary tract and the secretion of digestive juices are slowed down, so that the DIGESTIVE ABILITIES ARE ENFEEBLED. At the same time, the LIVER, KIDNEYS and other glands are either LESS ACTIVE or less able to stand being called upon to do extra work. The oxidative processes by which foods are utilized in the tissues go on more slowly and sometimes less completely, while the EXCRETION OF EXCESSIVE WASTE PRODUCTS is more DIFFICULT.

The lessened functional ability of these various organs and tissues makes it very desirable that they be spared the strain of handling an immoderate load. This is the part of discretion, in conserving organs and tissues which are beginning to wear out. Excessive intake of SALTS means added work for the kidneys which must excrete them; a diet with too much coarse FIBER in it may be the cause of intestinal irritation. A certain amount of fat is essential and makes food more satisfying but recently physicians have been warning that too much fat, especially when it is not needed as fuel for muscular work and is not properly utilized, "clogs up the liver." Also they

stress the advisability of limiting animal fats and foods high in the fat-like substance, cholesterol for persons with a family history of high blood pressure or coronary thrombosis. Brains, glandular organs and egg yolk are especially rich in cholesterol. Too much cholesterol in the blood is thought to be a possible predisposing factor toward hardening of the arteries and heart failure, due to plugging of blood vessels that nourish the heart (coronary thrombosis). As far as we know, however, a surplus of vitamins and liberal (but not immoderate) amounts of water are favorable rather than adverse factors even in old age.

A word may be in order concerning the place of mild stimulants such as TEA and COFFEE or the MODERATE use of ALCOHOLIC BEVERAGES. Most elderly persons experience comfort and cheer from hot drinks and hot coffee or tea slightly stimulates the motility of the digestive tract. Their stimulating effect may be welcome to those whose bodily processes are slow and less likely to be harmful than in younger persons who are under tension. They also help to keep up fluid intake. Except in certain diseased conditions (such as irritability of the heart), there is no reason for forbidding their use. Much the same may be said of alcoholic beverages. McLester says of them "In the feeding of elderly persons and those with debilitating disease they are of positive value. Such beverages taken with the meal often improve appetite and digestion."[4] Alcohol dilates the capillary blood vessels and thus may improve circulation temporarily. Touhy believes that the abuse of alcoholic beverages by some persons should not detract from their proper uses. He says of alcohol "as a vasodilator it inspires as well as flushes the aged," and of tobacco "It soothes and cuts off circulation. . . Tobacco is safer after 60 than before, because age has by that time made the blood vessels less elastic and labile."[5]

RECOMMENDATIONS AS TO DIET

From Forty to Sixty Years. Usually at about forty to forty-five years of age there appears a noticeable **inclination to put on extra weight.** This is due to a decreased amount of EXERCISE, to lessened MUSCLE TONUS and to diminishing activity of certain DUCTLESS GLANDS, especially the sex glands and often the thyroid. While a small increase in weight may be normal, and may even be advantageous in so far as it leads to greater nervous stability, an increase of more than 10–15 pounds in weight during middle age is distinctly disadvantageous and should be avoided. Life insurance figures show that above the age of thirty-five mortality increases about 1

[4] McLester, J. S., NUTRITION AND DIET IN HEALTH AND DISEASE, 4th ed., p. 237, W. B. Saunders Co., 1943.

[5] Touhy, E. L., "Feeding the Aged," p. 384, in HANDBOOK OF NUTRITION, A.M.A., 1943.

per cent for each pound above optimum weight (*i. e.*, "ideal" weight for twenty-five years and over; see tables on p. 510). There are very few overweight old people because overweight is a predisposing cause to diseases which prevent the overweight person from attaining advanced years.

It is far easier and wiser to cut down moderately on one's fuel intake (and take more exercise) when the tendency to put on weight FIRST manifests itself, than to try to take off excess weight by radical dieting or excessive exercising later on. In spite of popular opinion to the contrary, taking on excess weight can be prevented if one reduces the fuel intake enough and is consistent in maintaining the diet upon the lower level. The exact amount of curtailment necessary to prevent weight gain varies with different individuals. This advice should not be taken to support EXCESSIVE reduction in the amount of fuel foods with the desire of attaining UNDERWEIGHT (otherwise described as a willowy figure), which is fully as undesirable as overweight.

Beyond a slight reduction in the amount of fuel foods and some discretion as to the quantities of protein-rich foods and fats, no special modification of the diet is needed during this period. What has been recommended as the best diet for maintaining the body in health and vigor during younger years continues to be the "optimum diet" in later years—namely, a diet the basis of which is milk, cereal products, fruits and vegetables, with moderate amounts of meat, eggs and other protein-rich foods, cream, butter, sugar and sweets. The importance of milk, whole grains, eggs and green vegetables as "protective foods" still holds good.

Immoderate indulgence in foods that are of high fuel value, difficult to digest, and of salt, condiments, tea, coffee or other stimulants are indiscretions which must be paid for in time. "There is no greater fallacy than the idea that a man or woman can eat as if finishing himself or herself for the live-stock market and at the same time realize many of the worth while things of life. Many individuals do so and then turn themselves over to physicians and beauty parlor experts."[6] The years between forty and sixty are those when the habitual dietary indiscretions of earlier years are likely to produce their result in indigestion, high blood pressure, hardening of the arteries, disturbances of the heart and circulatory system, diabetes, and kidney disease. Then people flock to doctors in the hope that by some miracle the damage already done can be undone.

After Sixty Years of Age. In these years the diet should (1) be such as to ward off senility, and (2) it should be adapted to the lessened needs and functional abilities of the body.

1. For the purpose of preventing the degenerative changes in the tissues

[6] McCollum and Simmonds, FOOD, NUTRITION AND HEALTH, 2nd ed., 1928, p. 116.

which commonly develop in old age, the best diet is one which is rather MODERATE IN PROTEIN AND FATS, but one which PROMOTES INTESTINAL HYGIENE and PROVIDES AN EXCESS OF VITAMINS AND MINERAL SALTS. While the protein should be moderate to liberal in amount, much of it should be of the best quality, such as is provided by milk and eggs. A diet of moderate fat content makes for easier digestion and keeps down the fuel value to the lowered amount needed in later life. If the intestine is more easily irritated than with normal adults, it may be necessary to strain whole grain cereals or to use highly milled (white) bread and cereals which have been enriched, to give fibrous vegetables strained or finely minced, and to limit fruits to fruit juices, to soft raw fruits (such as banana), or to the cooked pulp of non-seedy fruits. Vegetables may also be given in the form of a purée in soups. Fruit juices, especially those from citrus fruits or tomatoes, are all the more important, when most vegetables and fruits are cooked, to give the needed quota of vitamin C (ascorbic acid). Giving fruits, vegetables, whole grain products and milk as prominent a place in the diet as possible, is an important aid in warding off senility, in that such a diet provides high quality protein along with liberal amounts of minerals and vitamins, and at the same time promotes intestinal hygiene.

2. In ADAPTING THE DIET TO the more FEEBLE BODILY CONDITIONS which often prevail in the aged, the suggestions which follow may be used wholly or in part as seems best in individual cases, and are sufficiently obvious dietary common sense to need no explanation:

Cut down the amount of fuel foods consumed considerably below the amount taken in middle life.

Include in the diet only simple, EASILY DIGESTED FOODS; avoid heavy sweets, rich foods, pastries, fried foods, hot breads, etc. Overindulgence in any food which is hard to digest may be a serious matter in old age.

Take fewer foods at a meal; eat smaller amounts at shorter intervals (*i. e.*, simple meals supplemented by mid-morning or mid-afternoon lunch of some such food as hot milk flavored with coffee, hot malted milk, a cup of tea or bouillon, fruit juice, etc.—any of them taken with a few crackers).

Use some hot drink or meat broth at beginning of meal to stimulate gastric secretion.

Some hot drink such as hot plain or malted milk given before retiring or in the night may relieve wakefulness.

Citrus or other fruit juices, tomatoes or tomato juice, and any soft raw fruits or vegetables that can be taken are needed as sources of ascorbic acid (vitamin C), otherwise often lacking in the diet.

A few crackers, a little fruit, or a cup of tea or coffee may be found helpful before rising, especially if the person wakens early.

As it is more difficult for the aged to keep warm and digestion is enfeebled, hot foods are welcome and are likely to be more easily digested than cold dishes.

When chewing is made difficult because of loss of teeth or poorly fitting artificial teeth, the food must be adapted to meet this condition—*i. e.*, more liquid or soft, semisolid foods should be given; crisp toast or crackers may be well managed dry or may be softened with broth, milk, coffee, etc.; the fiber of cereals, fruits and vegetables may be softened by cooking, and seeds, skins and pulp removed by straining; solid foods such as meats may be chopped fine, if necessary.

In general, the diet that is best adapted to the alimentary tract of the aged closely resembles that recommended for younger children—namely, milk and eggs, thoroughly cooked cereals (mostly whole grain or enriched), stale bread, toast or crackers, fruits and vegetables (mostly cooked soft but strained or pureed, if necessary), the leaner meats (finely cut if needed), soups, the simple desserts (custards, blanc mange, cereal puddings, etc.); these may be supplemented with easily digested nutriment between meals if desired, and with the addition of such mild stimulants as tea or coffee, which may be helpful or comforting in old age but are not permissible for young children.

QUESTIONS AND PROBLEMS

1. What are the two main general ways of holding off the processes of aging and prolonging life? Why do we have a greater proportion of people over 65 in our population now than formerly? Why do so many people in some of the Balkan countries live to great age?

2. What factors in the diet make for vitality of tissues, and hence longer life? What conditions of diet affect these conditions unfavorably? What are the most common causes of death at present?

3. When should a diet for preventing aging begin? What special changes in dietary regime should be made by persons between 40 and 50 years of age? What are the special dietary needs of people over 60 years of age?

4. Make a list of the foods that should be included daily in the diet of persons 40 to 60 years of age. Plan a day's menus for this age group, including all the essential foods in adequate amounts.

5. What are the special disabilities of the aged? How may the diet be

adapted to meet these special disabilities? Plan a day's menus for an 85-year-old man who is in fair health but rather feeble and has lost his teeth (has artificial dentures).

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CHAPTER 29

OVERWEIGHT: ITS SIGNIFICANCE AND TREATMENT

WHAT CONSTITUTES OVERWEIGHT. Overweight covers a broader field and is a much more prevalent problem than most persons realize. There is a huge army of people in the United States who suffer the disadvantages and dangers of overweight, without being so EXCESSIVELY fat as to be termed obese. One has only to watch the crowds in some public place frequented by the "easy-livers" (such as a hotel lobby or restaurant), to have a graphic demonstration of how large a proportion of our population is overweight. And how few of these people would admit that they eat too much, or that they would be more efficient and feel better if they weighed less. Most of them either do not realize that they ARE overweight or regard the matter as something determined by Fate rather than by themselves.

The tables on page 510 are guides to ideal weights for adults, of different heights and body builds, compiled recently by the Metropolitan Life Insurance Company. Because of the present prevalence of overweight among otherwise normal adults over forty years of age, the AVERAGE weights actually found in the later years of life do not represent the OPTIMUM weight so far as health is concerned. Although a well filled-out body and moderate store of fat constitutes a desirable reserve for the child or young adult, the gradual accretion of weight which so often comes in the latter half of life is undesirable and should not be accepted as normal. Physicians and life insurance companies now feel that, for the sake of health and longevity, it is best to carry no more weight after twenty-five or thirty than is normal for the height at that age. Slight variations from the theoretical normal are in order because of differences in body build and racial type; for adults, variations of 5–10 per cent over or under the average weight at thirty are probably of little influence on health. But an individual who weighs 15–20 per cent more than the theoretical normal for his height must be classed as distinctly overweight, while one who is 25 per cent or more overweight may be said to be OBESE.

TABLE XXXIV. IDEAL WEIGHTS FOR MEN 25 YEARS OF AGE AND OVER*

HEIGHT WITH SHOES		WEIGHT IN POUNDS (AS ORDINARILY DRESSED)		
Feet.	Inches.	Small Frame.	Medium Frame.	Large Frame.
5	2	116–125	124–133	131–142
5	3	119–128	127–136	133–144
5	4	122–132	140–130	137–149
5	5	126–136	134–144	141–153
5	6	129–139	137–147	145–157
5	7	133–143	141–151	149–162
5	8	136–147	145–156	153–166
5	9	140–151	149–160	157–170
5	10	144–155	153–164	161–175
5	11	148–159	157–168	165–180
6	0	152–164	161–173	169–185
6	1	157–169	166–178	174–190
6	2	163–175	171–184	179–196
6	3	168–180	176–189	184–202

TABLE XXXV. IDEAL WEIGHTS FOR WOMEN 25 YEARS OF AGE AND OVER*

HEIGHT WITH SHOES		WEIGHT IN POUNDS (AS ORDINARILY DRESSED)		
Feet.	Inches.	Small Frame.	Medium Frame.	Large Frame.
4	11	104–111	110–118	117–127
5	0	105–113	112–120	119–129
5	1	107–115	114–122	121–131
5	2	110–118	117–125	124–135
5	3	113–121	120–128	127–135
5	4	116–125	124–132	131–142
5	5	119–128	127–135	133–145
5	6	123–132	130–140	138–150
5	7	126–136	134–144	142–154
5	8	129–139	137–147	145–158
5	9	133–143	141–151	149–162
5	10	136–147	145–155	152–166
5	11	139–150	148–158	155–169

* From the Metropolitan Life Insurance Company Statistical Bulletin, October, 1942, June, 1943.

Its Causes. The chief causes of overweight are threefold—

(1) **Overeating.**
(2) **Inactivity.**
(3) Ductless gland abnormalities or emotional disturbances.

Of these the first two are decidedly more prevalent. As one grows older, he becomes more inclined to "spectator sports" than to active participation in games that call for physical exertion. We all walk less than formerly and many are in occupations that are mostly done sitting. A well-known authority on obesity states that 90 per cent of his patients grew too fat because of immoderate consumption of bread, which also tempts one to use a good deal of butter. It is not so much the actual bulk of food consumed as the **kind of foods habitually chosen.** Eating much of the concentrated fuel or HIGH-CALORIE foods is what leads to overweight. One stout person may be fond of SWEETS and STARCHY FOODS; another will eat much of the FATTY FOODS such as cream and butter, rich sauces, pastries and salad dressings, bacon, sausages and fat meats.

In either case the CHOICE of foods is such that the diet provides **more fuel than is needed** by the body from day to day, and the excess is stored as fatty tissue which gradually accumulates until the body becomes unsightly, unwieldy, and perhaps diseased. People with a tendency to obesity will store even a SLIGHT surplus of food intake as fat. In such a person even a good helping of butter or cream, taken DAILY in excess of body needs, may be responsible for adding 2 or 3 pounds to the weight in the course of a year, while if kept up habitually it would result in a 20–30 lb. gain in weight in ten years' time.

Persons whose MUSCULAR ACTIVITY is slight use much less energy than do those who exercise more, and hence tend to have a surplus of fuel intake over their needs even at a comparatively low level of food consumption. As they become overweight, they become less inclined than ever to physical activity, thus establishing a vicious cycle which leads to further weight gains provided the same habits of eating are kept up. Finally the muscles become so flabby and overlaid with fat, while the heart may be either surrounded with fat or weakened by fatty infiltration of its tissues, that exercise becomes difficult or even dangerous.

Although any person may become obese by continually eating too much, exercising too little, or both, there are some individuals who tend to put on fat more readily than the normal, so that they may be said to have a **natural predisposition to corpulence.** What causes this tendency to be stout, and is it possible to control it? In most instances, a family tendency to

stoutness does not come from any physiological pecularity, and has no more mysterious causes than such common family traits as unusually good appetite and digestion, or an easy-going and inactive temperament—combined with certain food habits such as having an abundance on the table, a preference for sweets, starchy or fatty foods, or an acquired habit of not feeling satisfied unless the stomach is unduly full. In a small proportion of cases, an inherited inactivity of some of the ductless glands (thyroid, pit-



Fig. 90.



Fig. 91.

Figs. 90 and 91. Malnutrition and obesity in the same family, showing that they are primarily due to food habits, physical defects, etc. rather than to heredity. The two boys are brothers. John is 12 per cent underweight, while James is 30 per cent over weight. The two girls are sisters, the one being 14 per cent underweight, and the other nearly 40 per cent overweight. (From Emerson, "Nutrition and Growth in Children," D. Appleton and Co., Publishers.)

uitary, or sex glands) may account for the family tendency to put on weight, either by slowing down basal metabolism or by causing other alterations in body processes which are little understood at present. Studies on groups of obese persons have shown that there is seldom any marked abnormality of the ductless glands, since their basal metabolism was about the same as in individuals of normal weight, when calculated per unit of surface area. However, it must be remembered that fat people lose heat

from their bodies less easily than thin people (due to the insulating effect of the layer of fat just under the skin), so that there is less need to use food for fuel to maintain body temperature.

Whatever explanation may account for the tendency, the person predisposed to obesity will put on weight on a relatively low food intake. On account of their general build, it is normal for such people to weigh 10–15 per cent more than the theoretical weight for their height, but they should not allow themselves to get heavier than this. It is far easier to adjust the food intake to a lower level and prevent taking on excess weight, than to reduce after one has once become obese. If there is evidence of ductless gland inactivity, the lacking gland extract should be given with care under the direction of a competent physician. In most cases, however, all that will be necessary to keep the tendency to corpulence within bounds is greater dietary vigilance and restraint than the normal individual needs to exercise. Although this may call for considerable self-denial, it is vastly preferable to carrying an enormous burden of extra flesh.

Since psychology has been much in vogue, physicians have come to the conclusion that fairly often people may overeat to compensate for emotional insecurity or frustration. The child who feels he is not wanted in the home or that the family is likely to be broken up, may become a large eater because food symbolizes security to him. The unmarried woman or the wife who feels she is losing her husband's affection may turn to eating to satisfy herself because of unfulfilled emotional desires. Such people need to have the cause of their unusual craving for food explained and to be made aware of the disadvantages of their behavior, and of course to have the undesirable emotional circumstances righted if possible. Persons must see advantages to be gained from changing food habits, before they are willing to do so.

Its Disadvantages. The disadvantages of overweight or obesity are sufficiently well known and have been discussed previously (pp. 124 and 308), so that we will merely enumerate them here in review:

1. INCONVENIENCE—difficulty in getting about, heaviness on feet.
2. DISFIGUREMENT—embarrassment, sensitiveness to ridicule.
3. INEFFICIENCY—lessened muscular activity, lack of ambition, sometimes mental sluggishness.
4. Predisposition to FUNCTIONAL DISEASES of the heart and circulatory system, kidneys and pancreas (diabetes).
5. LESSENED EXPECTANCY OF LIFE—due to 4, and also to fact that fat people have poorer chances of recovery in operations and in infectious diseases.

Overweight is especially prone to develop at thirty-five to forty-five years of age (for reasons see p. 504), and is especially disadvantageous after fifty. The dangers of overweight are naturally increased with a larger excess of weight and with advancing years. Life insurance figures show that, at the age period forty to forty-four years, an excess of 20 per cent in weight means a 30–40 per cent increase in mortality above the normal for those ages; while a 40 per cent excess weight involves an 80–100 per cent increase in mortality. Stating the same thing in another way, a man of fifty who is 50 pounds overweight may be said to have about half the expectation of life that a man of the same age has who is of normal weight. These figures are quoted because fat people are sufficiently averse to exercise and dietary self-denial, so that it seems necessary to make them realize the seriousness of overweight before they are willing to undertake a reducing regimen, or to persist in carrying it out.

VARIOUS PROCEDURES FOR WEIGHT REDUCTION

The numerous ways and means which have been suggested as efficacious for reducing weight may be grouped under four heads—

(1) Fake remedies.
(2) Ductless gland therapy.
(3) Exercise and baths.
(4) Special diets.

Fake Remedies. These include rubber garments, pastes and soaps for external use, bath powders, chewing gums, and various tablets, capsules, etc., for internal use. Most of these highly advertised nostrums are entirely ineffectual for reducing weight; some of them are harmless but sold at an exorbitant profit. In the directions on the package, the user is almost always told to cut down on total food intake, sweets and fats, and to take regular exercise. When such directions are followed, reduction in weight is likely to result but it is the directions, and not the so-called "remedy," which deserve the credit. A few of them do cause weight reduction, but contain harmful or dangerous substances (such as thyroxin or dinitrophenol). Others contain saline purgatives, which will interfere with food absorption but may lead to irritation of the intestinal tract or to the "cathartic habit." Some have even been shown to contain the ova of tapeworms!

Ductless Gland Therapy. Many of the more effective reducing remedies on the market contain thyroid gland tissue, or extracts of this gland. Thyroid material, if taken in sufficient quantity, will often produce marked reduction in weight by speeding up the basal metabolism and other body

processes. Overdoses of it may be very dangerous. Rapid pulse, palpitation of the heart, trembling of the limbs, tiny hemorrhages under the skin, headache, lassitude, fever, sweating, extreme nervousness and sleeplessness, are some of the symptoms which may result from the use of thyroid. Naturally, such a potent substance should not be sold for self-medication, and it should be used by doctors with caution and only when there is real evidence that the patient's thyroid is underactive. For normal persons, reduction in weight is far better effected gradually through diet and exercise, rather than rapidly through the use of powerful drugs such as thyroxin, dinitrophenol, or other chemical reducing agents.

Exercise and Baths. MUSCULAR WORK has a far greater effect in raising the energy consumption than any other factor. A very moderate amount of exercise may result in using 500 calories in excess of the amount required for maintenance, while more strenuous exercise may easily require 1000 calories, or even more. The fuel for doing this work must come either from the food or from the tissues; if part of the fuel foods taken in are used for doing muscular work, the excess left for forming fat will be less or may be reduced to the vanishing point. When the food intake is too low to provide the energy needed both for maintenance and for work, the body tissues will be called upon to supply part of the required energy and a loss in weight will result. Taking a moderate amount of exercise while on a limited food intake, thus constitutes one of the most efficient means of preventing the development of overweight and of bringing about a reduction of weight, when desired. Caution will be necessary, however, that the increased appetite does not lead one to a larger consumption of food, which will undo the effects of the exercise so far as weight reduction is concerned.

Some MILD form of EXERCISE should be taken REGULARLY and in considerable amounts, rather than resorting spasmodically to more violent exertions. Walking, calisthenics, golf or swimming are probably best adapted to overweight individuals, especially those over forty. When there are disturbances of the heart or circulatory system, exercise should be limited and should be adjusted to the patient's condition by advice of a physician. Special exercises to take weight off certain parts of the body (abdomen, hips, thighs, etc.) may be effective, but general exercise is also needed.

BATHS are often advised as a means of reducing weight. The COLD SHOWER or plunge has been shown to increase the basal metabolism considerably for some time, and hence may be a useful adjunct in weight reduction, if the individual reacts well after a cold bath. No other form of bathing has any real influence in causing loss of weight. Hot baths and SALINE BATHS may cause a temporary weight loss through sweating or

drawing out water from the body, but this weight is readily regained an there has been no real loss of solid tissue material. The same may be sai as to steam baths and massages now popular among the well-to-do. The recommendation of expensive bath salts for reducing is one of the mos common forms of quackery, and many of these preparations have as basis only such inexpensive substances as Epsom salts, alum, and washing soda, attractively colored and scented.

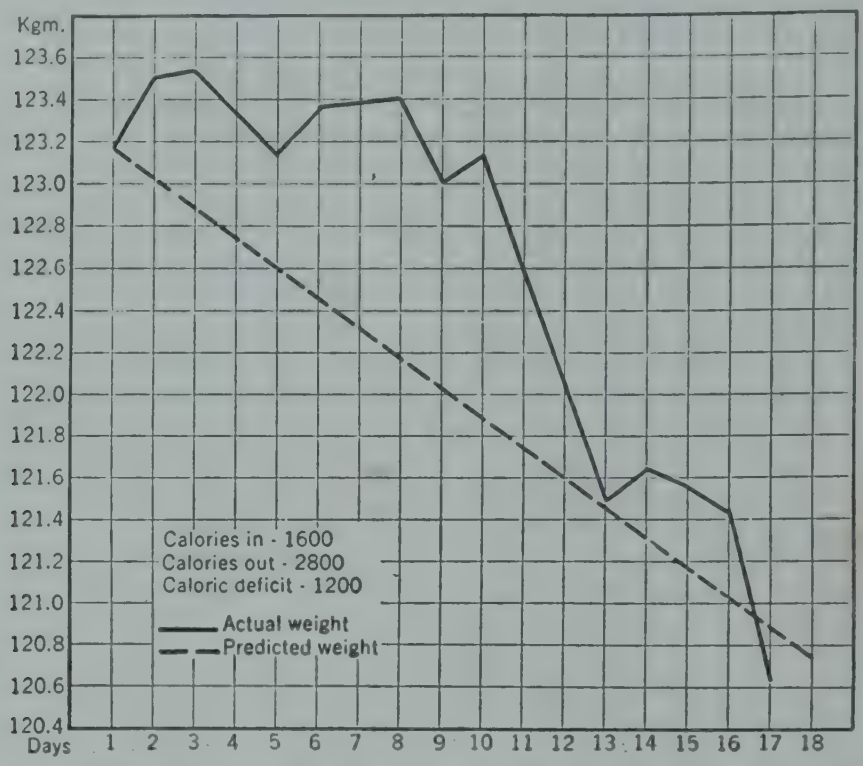


Fig. 92. Comparison of actual with predicted weight loss in an obese patient on a reducing diet, which furnished 1200 calories less than the caloric output. During the first ten days there was little weight loss (water retention balanced loss of fat), but in the following week weight loss was so rapid that the total loss equaled the amount predicted. (Newburgh and Johnston.)

Special Diets. CUTTING DOWN THE FOOD INTAKE MUST ALWAYS BE THE CHIEF RELIANCE FOR INDUCING LOSS OF WEIGHT. It does not matter exactly what form of diet is taken except that it must be LOW IN FUEL VALUE and should be a WELL-BALANCED diet, which will provide plenty of the proteins, mineral salts and vitamins that are essential to maintain health. The extremely one-sided diets often recommended for reducing are not only monotonous to take, but are likely to cause malnutrition and ill-health because of lack of various nutritive essentials, if persisted in for any length of time. **They have no special efficacy in causing weight reduction,** except that

a certain kind of person prefers the distinction of, and hence is more apt to keep on with, a peculiar diet than with one equally low in fuel value, better balanced but not so striking. As illustrative of these few-food diets we may mention the all fruit diet, the green vegetable diet, the potato diet, the pineapple and lamb chop diet, the raw tomato and hard-boiled egg diet, and the bread and butter diet.

While a diet solely of bananas and skim milk causes too rapid weight reduction to be recommended, these two foods supplement each other well and may be taken in moderate amounts for two meals daily when reducing. They constitute an inexpensive, easily measured diet which requires no preparation. One of its chief merits is that bananas leave the stomach slowly, so that one is less apt to feel hungry. The third meal should be chiefly of meat or egg, low calorie vegetables, salad, or fresh fruit.

Whole milk alone is sometimes used for effecting weight reduction in persons with heart disease. Its advantages probably lie in its low calorie value (approx. 675 C.), restricted fluid intake (no other fluid is given except 1 qt. of milk daily, taken in 5 portions at four-hour intervals), and low salt content; it should not be continued without additional food for more than a week or ten days.

For the ordinary overweight individual, the most satisfactory way to effect reduction is by simply cutting down sharply on the quantity of the more concentrated fuel foods (sugars, starchy foods and fatty foods), keeping on with an otherwise adequate and well-balanced diet. The essentials for a satisfactory reducing diet, which can be taken over fairly long periods without injurious effects, are that it should supply liberal amounts of good protein, vitamins, mineral elements and fiber, and be **inadequate** for body needs **in only one respect,** namely its **energy** content.

PLANNING THE REDUCING DIET

The chief things to aim for in planning any reducing diet are as follows:

(1) LOW CALORIE CONTENT.
(2) Relatively high protein content.
(3) Moderately low carbohydrate content.
(4) Very low fat content.
(5) Good satiety value.

The foods listed under "Foods to Use" are all **low-calorie** foods, except the protein-rich foods and desserts. A diet made up EXCLUSIVELY of clear soups, beverages, fruits and vegetables would be extremely low in fuel value, so that it would result in decided weight reduction, but it would

be lacking in protein and in staying qualities and would probably cause loss of weight at a more rapid rate than is advisable for the general welfare. Hence we enlarge the reducing dietary to include rather liberal amounts of LEAN MEATS, EGGS and SOFT CHEESES (which supply protein and are at the same time of relatively low fuel value), and SMALL amounts of a FEW CARBOHYDRATE FOODS such as bread, potatoes and very simple desserts. These additions give us a **better balanced** diet, and one on which weight will be lost at a more **moderate rate** without accompanying discomfort from hunger.

FOODS TO USE	FOODS TO AVOID Or take only in small amounts
Clear soups	Cream soups
Tea and coffee (without sugar or cream)	Breakfast cereals
Milk (especially skim milk or buttermilk)	Bread
Fresh fruits and canned or stewed fruits without sugar	Starchy vegetables
	Fatty meats
Watery and fibrous vegetables (especially green vegetables)	Rich dressings and sauces
	Rich desserts
Lean meats, eggs and soft cheese	Nuts and dried fruits
Small amounts of simple desserts	Sugar and sweets
	Cream
	Butter, margarine, or other clear fats

Other considerations make it advisable to have the reducing diet contain rather **liberal amounts of protein.** Fats must be almost entirely ruled out because of their high fuel value (two and one-fourth times as great as that of either carbohydrates or protein, p. 37). Sugars and starchy foods seem to have a special tendency to be converted into fat in the body, so need to be largely eliminated from the reducing diet. This means that a greater PROPORTION of the calories furnished by the diet will need to come from the protein-rich foods than in the normal diet. In addition (as explained on p. 139), the proteins have a STIMULATING EFFECT ON THE BASAL METABOLISM so that a protein-rich diet actually results in an increased consumption of fuel in the body. Hence a person would lose weight faster on a diet that furnishes an inadequate amount of calories but liberal protein, than he would on a diet that provides the same number of calories with carbohydrates and fats as the chief sources of fuel. For practical purposes, this means that one liberal serving and one small serving of lean meat, fish or poultry may be given daily (or meat with one meal and eggs with another), and in addition moderate amounts of milk and soft cheeses should be included in the diet.[1]

[1] The diet should provide 1 gram of protein per kilogram (2.2 lbs.) body weight in order to be meet the standard protein allowance, and at least 50 grams of protein daily to be adequate.

It is a little difficult to explain to the elementary student why it is advisable to include **small amounts of carbohydrate** in the reducing diet. If one starves, or eats a diet low in calorie value and almost free from carbohydrate, body tissues are burned up to furnish the energy needed for maintenance, including some protein tissues which it is undesirable to lose. Fats are not so completely oxidized under these conditions, and ACIDOSIS (excess acid in the body) results which is unfavorable to health. When a small amount of carbohydrate is included in the low-calorie diet, the tissue used up is chiefly fatty tissue, protein tissues are spared, and acidosis will not develop. The quantity of carbohydrate foods must be LIMITED if much weight is to be lost, but the inclusion of two or three THIN slices of bread (without butter), a SMALL amount of potato if desired, and one small portion of a simple, low-calorie dessert will help to make the reducing diet less harmful, as well as more palatable and satisfying.[2]

The **satiety value** of the diet is very important if hunger is to be avoided. Fluids and the liberal use of green vegetables give bulk to the diet but are not to be depended upon alone. Foods which require considerable chewing (crisp toast, crackers, salads, etc.) are also helpful in causing one to feel satisfied with a smaller amount of food. Meat is one of the foods with very high satiety value, and the taking of a small amount of fruit or simple dessert (sweet food) at the end of a meal will do much toward making one feel well fed. The fatty foods, which ordinarily can be depended upon for satiety value (see p. 38), must be ruled out of the reducing diet almost completely, but a SMALL amount of oil in salad dressing, or of cheese, may occasionally be included, while the use of eggs and milk will add some satiety value to the diet. By including the above-mentioned foods in small or moderate amounts, a diet the basis of which is nonnutritious fluids, greens and watery fruits may be rendered both palatable and satisfying.

The secret of planning a reducing diet which will cause loss in weight without any body injury, is to have the calorie content low enough to force the body to burn its FATTY tissues, but at the same time PROVIDE ALL THE

[2] Some authorities favor more carbohydrate and less protein in the reducing diet than others, but all agree that fats should be much restricted. The exact distribution of calories between protein and carbohydrate is not important so long as protein is adequate for body needs. It must be remembered that practically all of the energy value of fruits and vegetables comes from the carbohydrates that they contain, so that less concentrated carbohydrate foods, such as bread, cereals and sweets are needed than might be thought to give a safe quota of carbohydrate to prevent acidosis. One recommendation is that the diet will be well balanced and adequate in all respects except calories if fruits and vegetables furnish 40 per cent of the calories, protein-rich foods 25 per cent and milk 25 per cent; the remaining 20 per cent of the calorie intake will be from cereals, bread, sugar and a small amount of fats.

OTHER NUTRITIVE ESSENTIALS LIBERALLY. It is for this reason that milk, fresh fruits and nonstarchy vegetables should be so prominent in reducing diets—they are of low calorie value yet at the same time of good vitamin and mineral content. In fact, a reducing diet which consists chiefly of these foods may actually provide minerals and vitamins more liberally than the ordinary diet. Small amounts of other foods (eggs, meat, or cheese) may be needed to supplement the protein content of the diet, and it may be helpful to take some concentrate (such as halibut liver oil capsules) to supply extra fat soluble vitamins (especially if skimmed milk is taken and butter entirely omitted). Usually the large quantities of green or yellow vegetables taken can be depended on for vitamin A value; the B-vitamins are likely to be adequate but care should be taken to secure plenty of vitamin C from citrus fruits, tomatoes, and other raw fruits and vegetables.

In order to be adequate as to protein, mineral elements, and all vitamins, it has been recommended that the diet each day should include—

Milk—2 cups, to drink, on cereal, in soup or beverage

Vegetables—1 small potato ($2\frac{1}{2}$ in. diam.) may be taken in place of some of the bread. Several servings other vegetables, including a serving of leafy or yellow vegetable daily and raw ones often

Fruit—2–3 servings daily, including a generous one of citrus fruit or tomato

Protein-rich foods—at least 2 servings daily; count any item below as 1 serving:

- 4 oz. lean meat or fish
- 2 eggs
- 1 egg and $\frac{1}{2}$ c. cottage cheese
- $\frac{1}{2}$ c. cottage cheese
- $\frac{1}{2}$ c. cooked legume

Cereal and bread—2 or 3 servings, whole grain or enriched; small servings if the calorie value of the diet is very low; usually 1–2 slices bread plus small serving cereal or 3 slices of bread (no cereal) can be taken on a 1200 C. diet.

The remaining calories, if any, may be obtained from any other food, or from additional milk, fruits and vegetables.

Foods which are of such **high fuel value,** that they must be practically **eliminated from the diet when reducing,** are found listed under the heading "Foods to Avoid" on p. 518. Persons inclined to be stout should learn to take their tea or coffee without SUGAR and CREAM, and to like crisp toast without BUTTER, unsweetened fruits and desserts with only a little sugar in them. Small amounts of saccharin may be used for sweetening, but it is better if one can accustom oneself to taking foods less sweet. BREAKFAST CEREALS may be taken with some of the top of milk allowance and make a staying breakfast, but, if they are unpalatable without cream and sugar, they are best omitted. Cream soups, cream sauce on vegetables

and mayonnaise salad dressing should also be left out. Very small amounts of butter may be used in seasoning vegetables or on bread.

French dressing made with very little oil may be used on salads, or lemon juice (or vinegar) and seasonings used alone. Uncooked salad dressing of fairly low calorie value may be made by beating lemon juice with evaporated milk, or a cooked dressing made with egg, milk, vinegar and seasonings. The use of mineral oil in salad dressings is no longer countenanced by nutritionists as the mineral oil has been found to interfere with the absorption, and so rob the body of fat-soluble vitamins and certain mineral elements.

The SMALL allowance of starchy food may be taken in the form of potato, thin toast, or unsweetened crackers. Candy, cake, pie, and other pastries, rich puddings, whipped cream, rich sauces (as hard sauce, Hollandaise sauce, and mayonnaise dressing) and gravies, jellies, jams, marmalades and sirups, nuts, dried fruits and legumes, fried foods and fatty meats (sausages, ham, pork, fat fish, etc.) SHOULD ALL BE LEFT OUT OF THE DIET ENTIRELY although on RARE occasions one might indulge a craving for these foods by eating a very small amount.

The calories from any cocktails or other alcoholic beverages must be counted, since both alcohol and sugar in such drinks furnish body fuel. Sometimes these items are a source of additional calories (often unsuspected) in the normal diet, and thus contribute to overweight. A table of approximate caloric content of servings of alcoholic beverages will be found in the Appendix.

Skeleton Menu for Reducing Diet and How to Use It. It is entirely permissible for anyone to construct his own reducing diet, using whatever foods he has a preference for in such limited amount as will keep the calorie content of the food intake down to 1000–1800 calories. The exact number of calories which the reducing diet should provide, will depend on the size and activity of the person, and the rate at which it is advisable for him to lose weight, as explained more fully on pp. 525–526. A few persons with marked tendency to obesity and inability to exercise may need to go on a diet that furnishes only 800–1000 calories in order to lose weight satisfactorily, but the very low-calorie diets (600 C.) sometimes used do not have the endorsement of most nutritionists.

In practice it seems to place too much responsibility upon the individual and to be too confusing to leave him entirely without guidance in the selection of a reducing diet. Therefore, we have thought it advisable to suggest a **definite type of meal plan** for those who desire to reduce, leaving

considerable latitude for variety and choice of foods in making up individual menus. This we have endeavored to accomplish by presenting a skeleton menu for the reducing diet (p. 524), with many of the details as to how the menu shall be filled in left open to choice. The habit of following a definite meal plan, and acceptance of a certain regularity or monotony in diet as a matter of course, is of great help in making one contented on a more or less limited diet. To be always in quest of new food combinations is apt to keep one's mind on food to such an extent that one becomes discontented even with a fairly elaborate diet. Hence we believe that the use of the skeleton menu in planning reducing diets may be advantageous in three ways—

(1) Permits choice.
(2) Guides food selection.
(3) Induces regularity.

. With regard to directions for using the skeleton menus on p. 524, it seems necessary to elaborate mainly in showing **how choice and variety may be effected.** Variety may be introduced through using equivalent-calorie portions of different fruits, vegetables, soups, meats, beverages, cheese and egg dishes, salads and desserts as suggested in the lists on page 523.

Varying the Calorie Content of the Diet. The range of calories suggested in the skeleton menu is from 1200 to 1400 calories. It will be apparent that the fuel value of the diet may readily be varied within this range, raised above 1400 C., or reduced even below 1200 C. if desired, by simple **additions or subtractions from the menu.** To attain the lower level of 1200 calories, one would have to stick to the smallest portions indicated throughout, or else leave out some of the suggested foods. For example, omitting the fruit from breakfast, slice of bread and the cheese from lunch, and dessert from dinner would reduce the fuel value by about 350 calories. One could then either keep to the lower level of food intake, use the extra calories by taking larger portions of some of the other foods included in the skeleton menu, or introduce 350 calories in the form of some food not suggested here. It is better, however, to stick to the type of foods suggested and raise the calorie level by taking more liberal servings. All sorts of different combinations can be made, according as it is desired either to alter the form in which a given number of calories is taken, or to raise or lower the level of the calorie intake.[3] The 1200–1400 calorie

[3] Calorie values for average servings of most of the common foods are to be found in a table in the Appendix, pages 554 to 567 and a table of hundred calorie portions of common foods on pages 568 to 573.

Approximate 100 Calorie Portions of

Fruits

1 large apple, raw, or small apple, baked with sugar, or 1 cup unsweetened apple sauce
1 large orange
1 medium grapefruit
Medium large cantaloupe
1 medium banana
1½ pears (medium) or
2 peaches (medium)
Pineapple, fresh, 2 slices
1 cup berries

Simple Desserts

Gelatin desserts (plain), Fruit whip (from fresh fruits) — 1 cup
Sherbets and ices, Cup custard, Plain blanc mange — ⅓ cup
Cereal puddings, Ice cream — ¼ cup
Plain cookies, 1 large or 2 small
All desserts should be made not rich nor sweet, served without whipped cream or sauces. Scant the measures given above to keep within 100 calories.

Choice of Watery or Fibrous Vegetables

Average serving 10–50 calories
(approx. avg. 25 C.)

Artichokes, French (1)	Celery	Onions
Asparagus	Chard	Parsnips
Beets	Cucumber	Salsify
Beet greens	Dandelion greens	Squash
Broccoli	Eggplant	Spinach
Cabbage	Kale	String beans
Carrots	Kohl-rabi	Tomatoes
Cauliflower	Lettuce	Turnip

Other Foods

Clear soups—See the list of meat and vegetable soups on p. 391. Fat must be skimmed off the meat broths.

Beverages—Coffee and tea (clear, or sweetened with saccharin)
Whole milk—5 oz. (⅝ cup) = 100 calories
Skim milk, Buttermilk—10 oz. (1¼ cup) = 100 calories

Breads—Coarse breads such as Graham, whole wheat, rye or gluten breads are usually preferred, but are not essential since most of them have about the same fuel value as white bread.

Lean meats—Beef, lamb, mutton, chicken, turkey (roasted or broiled, eat lean portion only).

Lean fish—Cod, haddock, halibut, smelts, trout, whitefish, etc. (broiled or baked, not fried).

Eggs—Practically any way but fried or creamed.

Cheeses—Best keep to soft cheeses with lower calorie content, or use small amount Roquefort cheese in salad dressing, or small amount grated cheese as flavoring.

Salads—All green salads may be used liberally (lettuce, endive, escarole, romaine, chicory, cress, etc.)

Any combination of the fresh fruits and the watery or fibrous vegetables listed above may be used in salads, *e. g.*, apple and celery, shredded cabbage and pineapple, raw carrot and string beans.

Other foods—These may be used, as desired, by consulting tables of 100 calorie portions on pp. 568–573, in order to estimate the quantity that can be used and still keep within the calorie limits of the diet.

SKELETON MENU FOR REDUCING DIET

Approx. 1200–1400 Calories

	Calories
BREAKFAST:	
Fruit	100
2 very thin ($\frac{1}{4}$ in.) slices crisp toast (no butter)*	80
2 cups coffee with hot skim milk (about half and half), no sugar*	60–85
	240–265
LUNCHEON:	
1 c. clear soup	25
1 egg, OR small serving lean meat or fish	65–135
1 slice bread ($\frac{1}{2}$ in. thick), toast or roll	65
Large serving green salad with lemon juice or vinegar	00
Cheese, 1 in. cube solid cheese, or $1\frac{1}{2}$ in. cube cream cheese, or $\frac{1}{2}$ cup cottage cheese	80–100
Fruit (without sweetening), OR small portion simple dessert	100
	335–425
DINNER:	
1 bowl clear soup 1 cracker	50
1 large serving lean meat or fish	150—275
2 servings low-calorie vegetables (about 25 calories each) OR 1 serving vegetable and 1 small potato ($2\frac{1}{2}$ in. diam.)	50–90
Salad—green salad, dressing with vinegar and small amt. oil, OR —small portion salad of low-calorie vegetables or fruits, with small amount cooked salad dressing	50–75
Dessert—fruit without sugar OR small portion simple dessert	100
Beverage—$\frac{1}{2}$ c. coffee with $\frac{1}{2}$ c. hot milk, OR 1 glass buttermilk or skim milk, OR $\frac{3}{4}$ glass whole milk	75–110
	475–700

* If one prefers to use small amounts of butter and sugar, it is permissible to do so by cutting down on some other foods. Not more than 1 tbsp. sugar (50 calories) or 1 tbsp. butter ($1\frac{1}{3}$ average pats, 100 calories) should be included in a reducing diet, however, as most of the fuel allowance should be taken in the more bulky, less concentrated foods.

level makes a good reducing diet for most women (see paragraph on proper calorie level to use in reducing on pp. 525-6). Men usually need a slightly higher level of calories (1500–2000 C.) than women, because of their larger size.

Altering the Meal Plan. The reducing diet can readily be altered so as to allow of a different arrangement of meals from the one suggested here. Some regular system of meals should be adopted, however, and strictly adhered to, as only thus will a reducing diet yield the desired results. Moreover, it is almost essential that at least ONE MEAL IN THE DAY SHOULD BE VERY LIGHT in order to keep to the low calorie level.

For those who like a heavier breakfast, an egg (75 C.) OR small serving cereal with $\frac{1}{4}$ c. milk (not top milk or cream and no sugar) can be added to the breakfast suggested, and either lunch or dinner made lighter by the omission of 75–150 C. in some form.

Others will prefer to take the heaviest meal in the middle of the day, while some who find it hard to carry out a reducing diet at the table with those eating a full diet, may think it best to make two meals VERY light, taking them separately, and thus save enough of their calorie allowance for a full meal with the family at noon or night. In order to eat one good square meal (approx. 800 C.), however, on a 1200 C. daily quota; one would have to limit oneself very strictly on the other two meals (say 100 C. for breakfast and 300 for lunch; or 200 C. for each meal), which ordinarily will mean more hardship than to have the food allowance more evenly divided.

Some persons are less troubled with hunger if they use a little of their calorie allowance for midmorning, midafternoon or bedtime lunches—*e. g.*, midmorning, 1 apple or orange (50–100 C.); midafternoon, 1 cup tea with 1 tsp. sugar and slice lemon, 3 small unsweetened crackers (100 C.); bedtime, $\frac{2}{3}$ cup of hot skimmed milk (60 C.). Any arrangement most satisfying to the individual may be followed, providing it does not exceed the calorie allowance and is carried out consistently.

While the level of calorie intake does not have to be ABSOLUTELY the same each day, it is essential that the meal plan be such that the fluctuations made by choice in foods used will cause it to vary only within narrow limits (extreme variations not over 200–300 C.). This is one of the reasons why it is necessary to follow some definite plan of meals in order to get good results.

General Rules for Reducing Regimen

1. Those who should reduce—

Normal persons who are 20 per cent or more overweight.

Persons 10–15 per cent overweight, if they have a tendency to heart disease, kidney disease, gout or diabetes, should reduce to normal weight, or even slightly less.

Persons over forty years old, who have put on excess weight, may with profit reduce to their normal weight for twenty-five or thirty years of age.

2. How to find out the proper level of food intake to use for reducing.

Calculate your maintenance level (*i. e.*, the calorie intake necessary to maintain weight with normal activity) thus:

Look up (tables on pp. 510 and 575) the theoretical normal or ideal weight for your height and body build at 25 or 30 years of age.

Multiply this "IDEAL" weight (in pounds) by 15 if sedentary, and by 20 if active (adults require 15–20 C. per lb. per day).

This gives the maintenance level of calorie intake.

Plan the diet so as to yield 500–1000 C. per day LESS than the maintenance level, depending on how rapidly you want to lose weight.

EXAMPLE: A woman 5 ft. 5 in. tall, twenty-five years old, and of medium frame should weigh about 127–135 lbs. (actually weighs 167 lbs., about 25 per cent overweight, and is sedentary).

134 × 15 = 2010 calories, maintenance level.

Reduce calorie intake by $\frac{1}{5}$–$\frac{1}{3}$ of maintenance level.

2000 — 400 = 1600 calories.

2000 — 700 = 1300 calories.

Reducing diet for this individual should furnish 1300–1600 C.

3. How to determine how much to reduce food level in order to get a certain rate of weight loss.

One oz. body fat represents 275 C. of food.

If you cut down food intake 500 C. below maintenance level, you should lose about $\frac{3}{4}$ lb. per week, or 3 lbs. per month.

Cutting down 700 C. below maintenance level should result in weight loss at rate of a little over 1 lb. per week, or 4 lbs. per month.

A reduction of 1000 C. below maintenance, will cause weight to be lost at rate of 1 lb. 9 oz. per week, or approximately $6\frac{1}{4}$ lbs. per month.

You may not lose exactly at the calculated rate each week, especially the first week or two, but in the long run the weight loss will average about that expected, if you stick to your diet.

4. Weighing and best rate at which to lose.

Weigh once per week, on same scales if possible, at about the same time of day, and in approximately same weight clothing. Before the midday meal is good time to take weight. Small fluctuations of weight from day to day have no significance but steady, gradual loss of weight is what to work for.

It is not advisable to reduce more rapidly than 1–2 lbs. weight loss per week, and the lower rate of loss is the safer.

5. How long to keep on a reducing diet.

Stick to the diet until you attain the normal weight for your height and build; if naturally stocky in build or inclined to be stout, allow yourself to be 10–15 per cent above the theoretical normal.

If it is necessary to take off a good deal of weight, or if weakness develops, it is best to make one or more breaks in the dieting rather than continue too long; during such a recess from dieting it is essential not to eat more food than just enough to maintain weight at the new level, otherwise the weight lost may be regained.

6. Fast days and rest periods.

Some people get best results through having a fast day once a week, when they take only fluids, fruit, or greens. This tends to shrink the stomach and make one more satisfied with a small regular diet.

Other people think it wise to have a short rest period (about one week) from the diet after every 10 lbs. loss in weight; great care must be taken to keep the food intake down to the maintenance level during a rest period, so as to prevent a gain in weight.

Precautions

Those who should not reduce—

People who are of normal weight or only slightly in excess of it. Such persons lower their strength and resistance to disease, and are likely to become nervous and irritable by reducing to the point of thinness or underweight.

People who are naturally of stocky build should not try to reduce as far as the theoretical normal, as this is underweight for them. They will normally be at least 10–15 per cent overweight for height.

Very obese persons, who may have heart, kidney, or ductless gland complications and in whom weight loss must be severe, should have the advice of a physician in reducing and should not diet radically on some self-planned system.

Dangers of too rapid reduction.

May cause weakness, difficulties of heart and other organs, and throws a severe strain on the system for rapid readjustments in any event.

Detrimental to looks, as skin is apt to become wrinkled after the rapid loss of subcutaneous fat.

Hard on disposition, as the very restricted diet necessary will probably cause hunger and irritability or depression.

Do not be overambitious to reduce your weight too rapidly.

A less drastic diet kept up for a longer period causes less hardship and will leave one in far better physical condition.

Dangers of one-sided reducing diets.

If a reducing diet which is lacking in either protein, mineral elements or vitamins is kept up for long, weakness, anemia, increased susceptibility to disease, digestive disturbances, nervousness, or even deficiency diseases may result. Constipation may be caused by a diet low in fiber or bulk.

To avoid these dangers have plenty of fruits and vegetables (especially leafy vegetables, citrus fruit, and raw fruits and vegetables) in the reducing diet, and some milk, cheese, eggs and meat.

Penalties of breaking over diet.

ABSOLUTELY no food in excess of that allowed in the diet should be eaten. To fool or indulge oneself in this respect means either that you will not lose weight as desired, or that you will have to keep on the diet longer.

Take care not to have the portions larger than allotted, not to take "tastes" of other foods at or between meals, not to add extra calories in the form of sugar, cream, butter for seasoning, sauces, etc., which you do not count.

Necessity of keeping at lower level of food intake after reducing diet.

It should be obvious that, if you go back to the former food level on which you gained weight, you will regain the weight which has just been lost.

When you have lost the desired amount of weight on a restricted diet, increase the food intake GRADUALLY until you are taking just enough food to maintain constant weight. Keep the food intake at this new level. If you begin to gain, cut down the diet by a small amount.

With most normal individuals the level of food intake, which must be kept to in order not to regain weight, will not be sufficiently low to cause any hardship once one is accustomed to the new habits; with persons inclined to stoutness, extra care and restraint as to food habits will be necessary.

QUESTIONS AND PROBLEMS

1. Give four reasons why persons become overweight; how do you tell how much overweight a person is, and what are the dangers and difficulties of excess weight?

2. Is there any way (or ways) to reduce weight except by restriction of calories in the diet? What foods should be avoided or used only in small amounts in a reducing diet, and why? What foods may be used in quantity, and why? In which nutritive factor (or factors) must the reducing diet be low, and in which should it be adequate or better than adequate? Why? What food groups in the diet assure its adequacy?

3. Following the general meal pattern on p. 524, plan a reducing diet that will be adequate for all body needs except fuel, and furnish about 1400 calories. Revise this diet so as to drop out 400 C. and still have the diet adequate for body needs of an average adult, except for calories.

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CHAPTER 30

MALNUTRITION: HOW TO DETECT AND OVERCOME IT

MALNUTRITION VS. UNDERWEIGHT. The problem of MALNUTRITION is not confined exclusively to underweight. While underweight individuals are malnourished, not all malnourished people are underweight. One frequently sees persons who, although they are up to or may even exceed the correct weight for their height, yet are of low vitality or in poor health. They have usually been fed, either through necessity or preference, on a diet which supplied plenty of calories but was LACKING IN TISSUE-BUILDING MATERIALS (proteins and minerals) or body REGULATORS (minerals and vitamins).

That such persons are malnourished is evident in a number of ways, even though there may have been satisfactory weight gains and enough subcutaneous fat to make them look well nourished to a superficial observer. The weight increase is due chiefly to fat deposits and also somewhat to water held back in the tissues, rather than to the building of muscle, organ tissues and bones. Their color is usually poor, their flesh flabby, and their bones and teeth of poor quality. Such individuals are often ANEMIC, LISTLESS, TIRE QUICKLY, TAKE INFECTIOUS DISEASES READILY, and, when seriously ill, are more apt to succumb than those who have better nourished tissues and greater vitality. These persons must be counted among the malnourished as well as those who are underweight. One class may be said to have been UNDERfed, while the others have been WRONGLY fed.

What Constitutes Underweight and When It Is Dangerous. Although frequently spoken of as if synonymous with malnutrition, the term underweight should not be so used. Not only are there malnourished persons who are not underweight, but, under certain conditions it is normal or even advantageous to weigh somewhat less than the usual weight for a given height and age. The terms underweight and overweight really indicate nothing more than a **variation from the average** weight, as determined by measurements and indicated in tables. The average weights found are not necessarily the normal or the best for every individual. For

children and young adults, it is a distinct advantage to be about 10 per cent above the average weight for height, as this slight excess represents a margin of reserve to draw on in case of need and protects the body in several ways. On the other hand, from middle life on, a slight degree of underweight is advantageous to health and expectation of life. It is with **children** and **young adults** that underweight is almost sure to be a disadvantage and may be dangerous to health, if excessive.

In general we may say that to be as much as 7–10 per cent below the average weight for one's height usually means lowered vigor and physical efficiency, while to be **more than 10 per cent underweight** is apt to mean a reduction of vitality and stamina such as may be dangerous. It is normal for some individuals of the tall slender type (see pp. 296–300) to weigh slightly less (5–10 per cent) than the average figure for their height, but too wide variations from the normal should not be complacently accepted. Although it is more difficult to fatten this type of person, a good deal can often be done to overcome the natural predisposition to leanness, and health may be much improved by a 5–10 lb. increase in weight. Moreover, many more people are underweight because of wrong habits of eating or living, or because of some physical defect or diseased condition than because of a hereditary predisposition to be so (see Figs. 90 and 91, p. 512), although they are prone to advance the latter explanation rather than to make any effort to find and correct the real cause or causes. This group, in which probably the majority of cases of typical malnutrition would fall, usually can be strikingly benefited by a fattening and upbuilding diet.

The **disadvantages** and **dangers of underweight** need some further explanation. The normal amount of fatty tissue is very useful in the body not only as reserve fuel but as padding about the nerve plexuses, and to buoy up the abdominal organs and keep them in place. Accordingly, the very thin person is almost sure to be HIGH-STRUNG and NERVOUS, and unless special care is taken to prevent it, the viscera are likely to sag out of normal position. In addition the poorly nourished muscle tissues become flabby and relaxed, including the muscles of the abdominal wall and the muscle coats of the intestines. Such persons suffer from NERVOUS INDIGESTION, CONSTIPATION and a wide variety of ILL-DEFINED AILMENTS. There are great numbers of them who go the rounds of doctors in a vain effort to find out why they do not feel well, only to be told in most cases that "there is nothing organically wrong" or "the chief difficulty is nervous." Their distress is real enough, but nothing constructive can be done for them without a general course of **upbuilding** which often would require, in order to be effective, not only change of diet but correction of bad

posture, bad habits of living, and often a change of mental habits as well (see Chap. 17 for discussion of how these factors may influence nutrition favorably or unfavorably).

In addition, malnourished individuals are usually listless and fatigue easily, or keep going only under strain, so that they are constantly suffering from ACCUMULATED FATIGUE whether they realize it or not. They also show a DIMINISHED RESISTANCE TO DISEASE and generally lowered vitality. TUBERCULOSIS occurs most commonly among undernourished young people and mortality in the early twenties has been shown to increase 1 per cent for every pound below average weight for height. The recent fad for reducing among adolescent girls and young women is probably responsible for the fact that the amount of tuberculosis at these ages has increased in the past few years, although during the same period the extent of the disease was much reduced among all other age groups. Tuberculosis is one of the diseases that has increased most strikingly among the malnourished people of Europe as a result of their long period of underfeeding both during and after World War II. In every country there are poor people who are victims of underfeeding even in peace time.

These facts are summarized in the table below:

DISADVANTAGES OF SLIGHT UNDERWEIGHT.	DANGERS OF EXCESSIVE UNDERWEIGHT.
Scrawny appearance Tendency to chill easily (due to lack of subcutaneous fat)	Anemia
Irritability and nerve strain	Morbid nervous conditions or nervous exhaustion
Lack of ambition (or desire to play in child)	Sagging of viscera, which may lead to functional disorders
Lack of ability to concentrate	More serious infections such as tuberculosis, pneumonia, etc.
Fatigue easily	Vitality seriously impaired
Digestive disturbances or constipation	
Susceptibility to minor infections—colds and other diseases of respiratory tract, skin infections, etc.	

The **average weight** of boys and girls at given heights and ages may be seen from the tables included in the Appendix, pp. 576–581. Variations in height and yearly weight gain which may be expected according to whether the child is short, of medium build, or tall for its age, are listed below the regular weight tables for children of school ages.

To **ascertain the nutritional status** of a child, take the weight and height carefully (with shoes off), find in the table the expected weight for a child of that HEIGHT and AGE, and calculate what per cent the number of pounds by which the actual weight deviates from this expected weight is

of the IDEAL weight. A child who is 10 per cent (or more) underweight probably should be examined by a physician; children who seem in poor general condition, whatever their weight, should be examined to see whether they show other evidences of malnutrition.

Adults may check their weight in the same way by means of the tables of AVERAGE WEIGHTS on page 575, and "ideal" weights on page 510, and

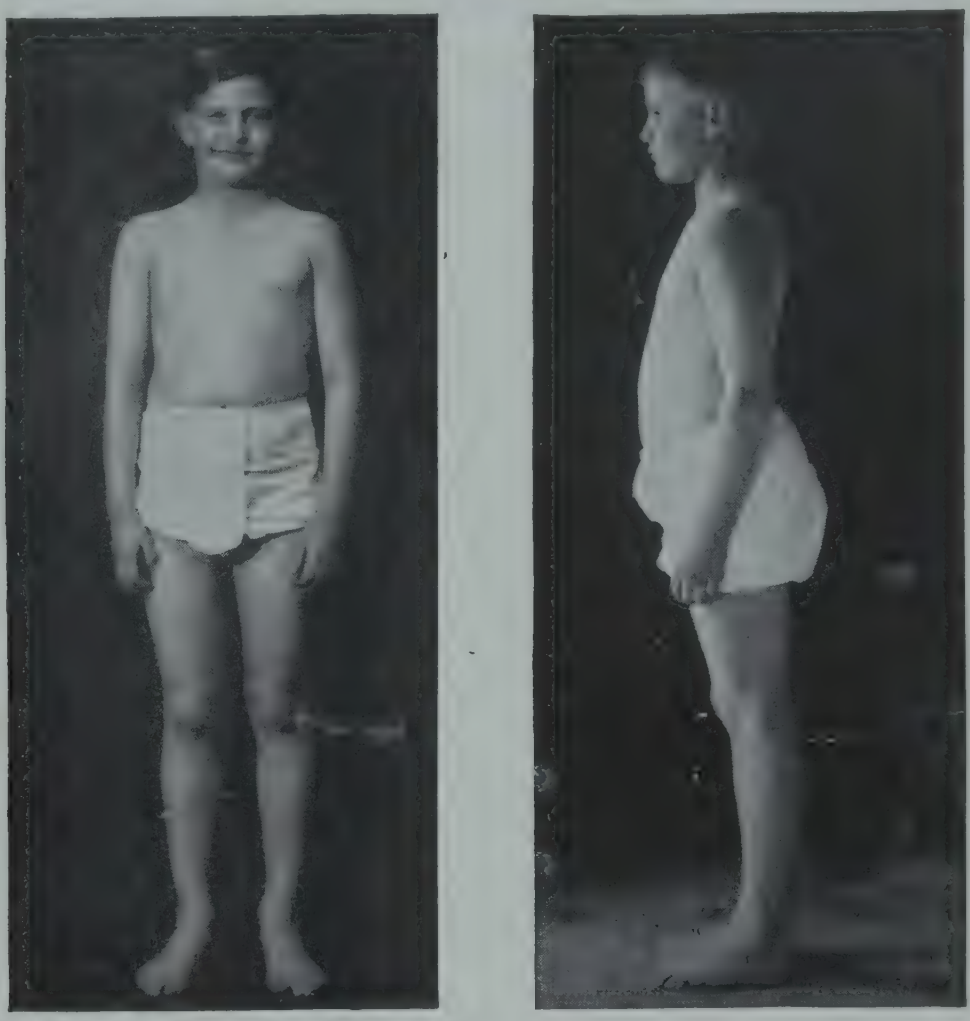


Fig. 93. A well-nourished ten-year-old boy, who has practically all the characteristics of good nutrition listed in the text, and whose diet and program of living are in accord. (From Roberts' "Nutrition Work with Children," Univ. of Chicago Press, Publishers.)

they may check general nutritive condition by the lists of symptoms of good or poor nutrition on page 535.

Malnutrition Defined and How to Detect It. Malnutrition may be described as a state in which either THE FOOD INTAKE IS INADEQUATE IN SOME RESPECT to meet the body needs, or in which physiological and environmental CONDITIONS ARE SUCH THAT THE BODY IS UNABLE TO UTILIZE

SUFFICIENT FOOD MATERIALS to provide for its proper growth, maintenance and repair. Such a deficiency will be **most likely to occur and most serious in youth,** when the demands for calories to meet the high basal metabolism and muscular activity, and for building materials and calories to cover the growth needs, are much greater proportionally than in adult life.

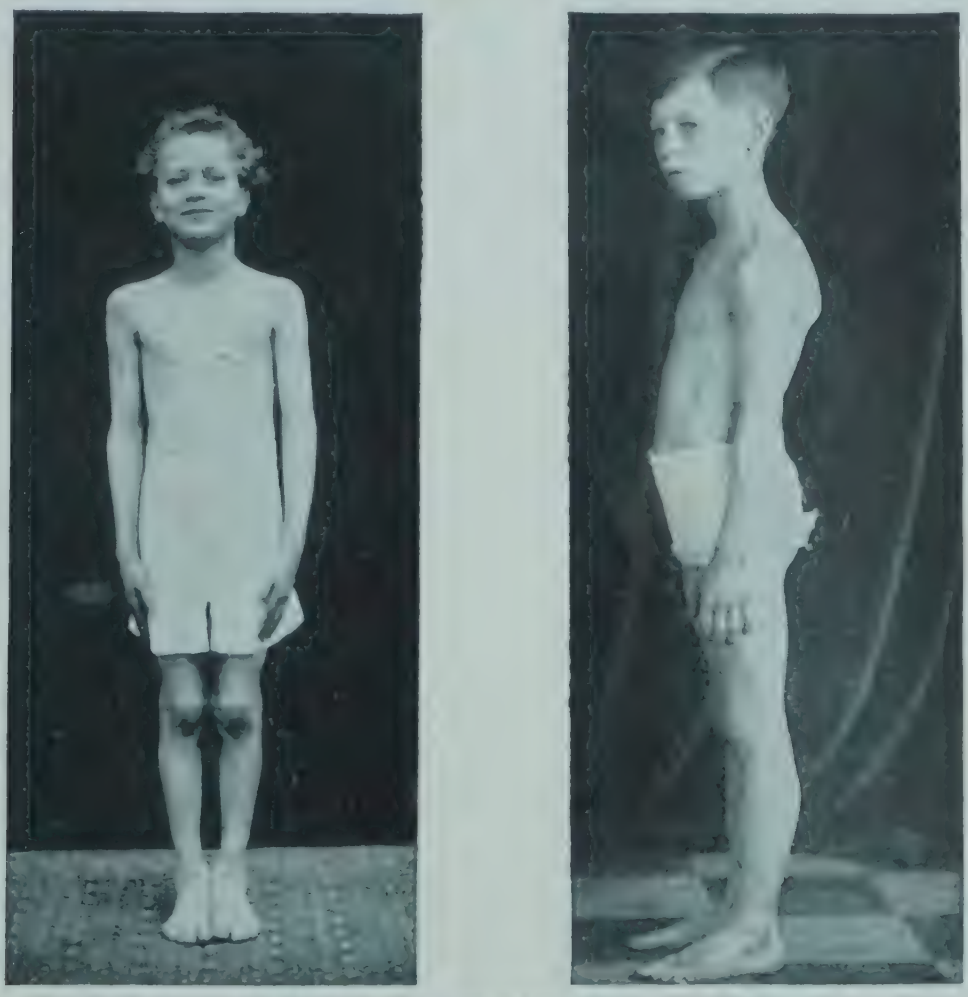


Fig. 94. Two examples of poor nutrition chosen to show different types. The boy at the left is of the extreme thin type. Though his facial expression is bright, there is a strained look about it, and it is apparently an effort to hold himself even as erect as he does. (Picture by courtesy of the U. S. Bureau of Home Economics.) The ten-year-old boy at the right is stunted both in height and weight, and has the posture and expression of a little old man. (From Roberts' "Nutrition Work with Children," Univ. of Chicago Press, Publishers.)

It should be recognized that malnutrition may be brought about in many different ways. The food may be inadequate either as to QUANTITY or QUALITY; or the food supply may be all right, but DIGESTION and ABSORPTION be so poor that the food materials are not taken into the blood stream; a disabled heart may fail to pump the blood to the tissues properly

or other factors may interfere with good CIRCULATION in the tissues. Some factor like ADENOIDS or bad POSTURE may prevent a good reoxygenation of blood in the lungs. LIVING HABITS or ENVIRONMENT, which react upon the individual so as to bring about poor appetite, aversion to particular foods or refusal to take food, poor digestion, overfatigue, etc., are naturally unfavorable to nutrition, as are also absorbed toxins from various INFECTIONS in the body. In short, anything which tends to make the food intake lacking in some essential material or low in total amount, and anything which interferes with the normal processes by which food is utilized in the body, will tend to bring about a malnourished condition, which will be more or less severe depending upon the EXTENT of the deficiency thus brought about.

We usually **detect** malnutrition by certain outward **signs** which are the effects produced by that condition. It would seem to be an easy matter to tell whether a person is well or ill nourished, and it is true that to the trained eye such differences in nutritive condition seem obvious and are quickly noted. However, it must be remembered that there are all degrees of malnutrition, and that the average individual is not apt to look at himself or his own child with unprejudiced eyes. So-and-so is merely a little delicate, or plays so hard that he couldn't get fat, or is in the stage where he is growing tall so he is naturally thin, or inherits his father's lean tendency. These are well-worn alibis for refusing to recognize malnutrition as such. In practically all such cases extra weight could be put on and health improved by increasing the food intake and correcting the bad habits or physical defects responsible for malnutrition.

Often the parent assumes that the child is all right because he has no high standard of what a healthy child should be. For this reason, a list of some of the more striking **characteristics** of the **well-nourished** individual, contrasted with those usually found in **malnourished** individuals is given. The student should observe carefully the pictures of children in good and poor nutritive condition shown on pp. 532 and 533, and compare them with the characteristics listed in the table on p. 535, to see how completely those children illustrate the signs of good or poor nutrition as enumerated in this table.

Nowadays physicians and school nurses are trained also to look for signs of deficiency of any specific vitamin. They observe the eyes carefully for inflammation about the cornea that may be the result of riboflavin deficiency and ask if there is difficulty in seeing in dim light (result of vitamin A deficiency). They look carefully at the mucous membranes of the mouth and at the tongue for signs of deficiency of niacin or riboflavin.

Characteristics of Good Nutrition	Characteristics of Malnutrition
Well-developed body	Body may be undersized, or show poor development or physical defects
About average weight for height	Usually thin (underweight 10 per cent or more) but may be normal or overweight (fat and flabby)
Muscles well developed and firm	Muscles small and flabby
Skin turgid and of healthy color	Skin loose and pale, waxy or sallow
Good layer subcutaneous fat	Subcutaneous fat usually lacking
Mucous membranes of eyelids and mouth reddish pink	Mucous membranes pale
Hair smooth and glossy	Hair often rough and without luster
Eyes clear and without dark circles under them	Dark hollows or blue circles under eyes
Facial expression alert but without strain	Facial expression drawn, worried, old OR animated, but strained
Posture good: head erect, chest up, shoulders flat, abdomen in	Fatigue posture: head thrust forward, chest narrow and flat, shoulders rounded, abdomen protruding
Good natured and full of life	Irritable, overactive, fatigues easily OR Phlegmatic, listless, fails to concentrate
Sleep sound	Difficult to get to sleep, or sleeps restlessly
Digestion and elimination good	Subject to nervous indigestion, constipation
Appetite good	"Finicky" about food
General health excellent	Susceptible to infections Lacks endurance and vigor

They inquire as to appetite and test nerve reflexes as a clue to deficiency of thiamine. They sometimes take x-ray pictures of bones to see whether ossification has been or is taking place satisfactorily (especially in the ends of bones), and an unsatisfactory picture will indicate lack of enough vitamin D or calcium or both.

These are visible signs, but we can go even further in order to detect milder grades of malnutrition. Chemical analyses of the blood may be made to determine whether a low level of any certain vitamin in blood points to insufficient supply of one or several vitamins. Excretion of the vitamin in the urine can be determined after giving a test dose of it; excretion of abnormally small proportion of the vitamin given indicates that it has been taken up instead by the blood and tissues which had too low a supply because of lack of that vitamin in the diet. These tests work especially for the water-soluble vitamins and we rely especially upon such

means to see to what extent the body is or is not "saturated" with ascorbic acid (vitamin C).

Prevalence. The amount of malnutrition that exists in the country will depend upon the standards we set for good nutrition. If one takes only those who are markedly underweight or show gross signs of poor physical condition, the numbers may be reassuringly few. If we go to the other extreme and class everyone as malnourished in whom chemical tests show that the body is not "saturated" with certain vitamins (especially vitamin C), a lot of apparently healthy people will be included and the numbers will be alarmingly large. At the Conference on Child Health in Washington in 1941, the objectives were stated as in three stages—

first, to eliminate deficiency diseases and more obvious cases of dietary deficiency;

second, to locate and bring up to par the border line cases of deficiency;

third, to raise the nutritional status of the population as a whole.

A trio of nutritional experts,[1] appointed by the National Research Council to assess the real extent of malnutrition in the country, believe that the first objective is well underway to accomplishment, but that much remains to be done as to the second and third objectives. The following quotation is from their report:

"Some types of malnutrition are strikingly obvious to everyone, some are apparent only to the physician who looks for them, and some are vague and elusive even to the careful observer using the most accurate specialized techniques. If the first group alone is counted the prevalence of malnutrition will be recorded as low, almost negligible. If the second group is counted it will be recorded as high. If the third group is included then the rate will be sufficiently high to occasion genuine concern."

The statement is often made that about 30 per cent of our population is malnourished, although conditions vary in different sections of the country, at different economic levels, and according to the standards used in judging malnutrition. When surveys are made of family food supplies or foods consumed by individuals (dietary records), and the results are judged by comparison with the "yardstick" of recommended allowances of the National Research Council's Food and Nutrition Board, the conclusions are apt to be misleading.[2] These allowances were set as a reasonable "optimum" toward which we should strive for the betterment of nutrition; they include a "margin of safety," so that a person whose intake of certain nutritive factors is not up to the recommended allowance is by

[1] Jolliffe, McLester, and Sherman, "The Prevalence of Malnutrition," J.A.M.A., v. 118, p. 944, 1942.

[2] Wilder, R. M., "Misinterpretation and Misuse of the Recommended Dietary Allowances," Science, v. 101, p. 285, 1945.

no means necessarily malnourished (though he may be if the shortage is too great).

Since malnutrition is most apt to occur in growing children and the proper nutrition of our children is a matter of great concern, we may briefly note a few recent surveys, keeping in mind the cautions as to conclusions noted above. Wiehl[3] examined the diet histories of some 2000 high-school pupils in New York City; 28 per cent were getting less than two thirds of the calcium allowance (Food and Nutrition Board), 38 per cent getting less than two thirds the vitamin A allowance, while 25 and 29 per cent fell below the two thirds level of riboflavin and ascorbic acid, respectively; many got less than the full allowances for some or all nutritive essentials, but those mentioned above were the most serious deficiencies. Mack and coworkers[4] made studies on 575 children, some in an industrial community and some in a college town; those in the industrial section ate less of the "protective foods" than those in the college community but there were some even in the better educated families who were consuming too little of these foods, even amounts so inadequate as to lead to malnutrition. Probably the statements made over the radio (in advertising synthetic vitamins) that three out of every four persons are getting too little vitamins are considerable over-estimates due to misleading use of the "yardstick" of optimum allowances. Nevertheless, surveys of school children too numerous to cite, surveys based only on underweight and visible evidences of malnutrition, have given evidence that about a fifth of these children were malnourished even by these standards. In this country, we are trying not only to eradicate gross malnutrition, but to raise the nutritional status and health of all the people.

Malnutrition is more prevalent in other countries than in the United States. Surveys in most of the European countries (Spain, Holland, France, Italy, etc.), most of them made since the end of World War II, have shown wide-spread and tragic undernourishment, especially among women and children. Not only physical weakness is prevalent among these underfed peoples, but tuberculosis and other diseases are much increased, anemia is frequent among women, fewer babies are born of starved mothers and many of these die. Such human misery due to chronic underfeeding is also prominent among the teeming populations of the Orient.

Causes and Prevention of Malnutrition. As it is necessary to point out the causes of malnutrition in small space here, and since they are sufficiently obvious and common to need little discussion, they have been

[3] Weihl, D. G., Milbank Mem. Fund Quart., v. 20, p. 61, 1941.
[4] Mack, P. B., *et al.*, J. Am. Dietet. A., v. 18, p. 69, 1942.

presented in outline form below.[5] This has the additional advantage of showing at a glance how different causes are related. In view of the fact that we are concerned in this book chiefly with the dietary factors, these are given in slightly greater detail, but it must not be assumed that they are more important. While it is usually necessary to locate and remove SEVERAL faulty habits or defects, which are operating jointly to cause the poor state of nutrition, almost ANY SINGLE FACTOR, if sufficiently severe and long continued, will produce malnutrition. An effort should be made to correct physical defects, faulty health habits and unfavorable environmental conditions, so that all conditions may be as favorable as possible for making nutritive gains, *i. e.*, to REMOVE UNFAVORABLE FACTORS so that the individual is "FREE TO GAIN" when the diet is altered for the better.

- Causes of malnutrition
  - Direct causes
    - Faulty diet
      - Too little food
        - Lack of appetite
        - Inadequate breakfast or lunch
        - Not enough food provided
        - Low calorie foods chosen
      - Food inadequate in kind
        - Too little milk
        - Too few vegetables and fruits
        - Too much candy and other sweets
        - Use of coffee and tea
      - Bad food habits
        - Between-meal eating
        - Hurried meals
        - Irregular meals
    - Faulty hygiene
      - Too little sleep
      - Too little fresh air and sunshine
      - Chronic fatigue
      - Bad posture
      - Bad tonsils or adenoids
      - Bad teeth
    - Defects and disease
      - Tuberculosis
      - Syphilis
      - Other infections
      - Hookworm
  - Underlying causes
    - Lack of home control
    - Ignorance
    - Poverty

The **underlying causes** of malnutrition in children have been stated to be IGNORANCE, LACK OF HOME CONTROL, and POVERTY. These are the home or community conditions responsible for the factors that cause the malnutrition. The two first named are probably the more prominent, for malnutrition is by no means confined to homes where the income is low. In fact, living conditions among the wealthy are such as to cause a high percentage of malnourished children in these homes. On the other hand, if one has not the money to buy enough food or to provide more expensive but essential foods such as milk, fruits and vegetables, it is impossible to prevent malnutrition. Lack of ability to realize cause and effect relations, prejudices against certain foods or hygienic measures, ambition of parents to push children too hard at school or in outside activities, refusal to rec-

[5] This outline is condensed (with slight alterations) from a chart showing the causes of malnutrition and their relationship, contained in Roberts, NUTRITION WORK WITH CHILDREN, 2nd ed., Univ. of Chicago Press, pp. 170–71, 1935.

ognize the condition for what it is, ignorance of how to go about remedying it, are all variations of the ignorance factor.

The lack of home control is patent among wealthy, middle class and poor alike, although possibly more prevalent at both extremes of economic status. The children of the rich are apt to be overindulged and left to the care of servants who have little interest or authority, while the children of the poor are deprived of supervision and left to fend for themselves because the parents are at work. Moreover, Americans are noted for laxness with their children and undue indulgence of the children's whims. "Life for many undisciplined children is one unbroken series of dissipations," says Emerson, and a prominent child specialist estimated that 85 per cent of his cases were fundamentally due to this cause of lack of parental control. Of course, once parental control has been lost, it is difficult to reestablish it sufficiently to carry out any health program even with the best of intentions on the parents' part, so that securing cooperation of the child himself is essential. But why place such a responsibility upon the shoulders of inexperienced children? Parents do not usually allow children to decide what they will wear, whether they will take music or dancing, and what they will study at school, but they do constantly leave the children to decide what they will or will not eat, and when they will go to bed.

This leads us to the subject of the **prevention** of malnutrition. This is an extremely important subject which can be discussed only briefly, but we hope that the classification and discussion of the causes of malnutrition given above will make more or less obvious the measures necessary to clear it up or to prevent its occurrence. The DIRECT causes (see outline, p. 538) must be gotten rid of and the conditions responsible for them (UNDERLYING causes) must be remedied, so far as is possible. The family with an income insufficient to buy suitable food must receive help through some proper agency; educational propaganda of various sorts must be used to make people realize the prevalence of malnutrition and its causes; either the parents must take charge in some constructive health program for the child, or the child must be guided by teaching in the schools to reorganize its own diet and habits of living so that these factors will be favorable to good nutrition.

The chief agencies, through which such educational and remedial measures have been carried out, are individual advice of physicians, books and magazine articles, mothers' clubs, infant and prenatal clinics, nutrition classes and general instruction in diet and hygiene given in the schools, and the work of various child welfare organizations. School lunches have been an important factor by supplying supplementary food for children of

low-income groups and teaching good food selection to all, even to the mothers who may take part in the project. Until recently child welfare work has been chiefly dependent upon private contributions, but now various federal, state and city agencies are being created and empowered to spend public funds for the betterment of child health. One may expect that these enlarged efforts in behalf of public health will in time effect a considerable reduction in the prevalence of malnutrition.

Treatment of Malnutrition. While numerous organizations are endeavoring to see that the present generation of infants and small children has a better start in life, from a nutritional standpoint, than many of their older brothers and sisters did, we have a great many cases of ESTABLISHED malnutrition among both children and adults, which should receive TREATMENT. In order to be effective, this treatment must follow two lines—

(*a*) **Location** and **removal** of the **contributory causes** of malnutrition.
(*b*) **Improvement of the diet.**

Under the first head, comes a thorough study of the person's DAILY PROGRAM to discover whatever faulty food and health habits there may be, and a general MEDICAL EXAMINATION to see whether there are any physical defects which need to be corrected. These unfavorable factors that predispose to poor nutrition must then be remedied—bad habits of living corrected, physical defects and disease receive proper treatment. Often considerable persistence may be needed to locate ALL the causes which are holding the individual back from gaining. If there is not satisfactory gain in weight and improvement in health after the more obvious causes have been located and corrected, and after an upbuilding diet has been given, further search should be made for there is certain to be some factor that remains undetected or that has not cleared up as expected with treatment, which is responsible for the inability to gain. OVERFATIGUE is one of the most common causes and is easily corrected by longer hours of sleep, rest periods during the day, and reducing the activities which cause the fatigue. BAD HABITS OF EATING AND HYGIENE and, to a certain extent bad posture, can be remedied by self-help, but medical or dental aid will be needed to check up on and get rid of PHYSICAL DEFECTS and INFECTIONS. More severe and less obvious cases will often require continued observation and study by a physician, or in a nutrition clinic or class, in order to locate and treat the factors responsible for keeping the person below par physically. The **effects of treatment** for malnutrition can be seen in Figures 95 and 96.

Feeding a suitable diet is perhaps the most important single measure for improving malnutrition—certainly an adequate food supply is indis-

pensable. The corrective diet may be started at once—*i. e.*, while one is in the process of locating and clearing up the unfavorable contributory factors as outlined above. While the body may not be able to take FULL advantage of the upbuilding diet until all the adverse factors are remedied, the diet given meantime should be of the best type, and this in turn may help to remedy defects and diseased conditions more quickly, and to strengthen



Fig. 95.



Fig. 96.

Figs. 95 and 96. Effects of treatment for malnutrition. The two boys at the left were refused working certificates because they were seriously underweight. Their backs present undeniable evidence of malnutrition in the projecting and uneven shoulder blades and spinal curvatures. At Camp Harlow Arden, near Chicago, the camp schedule conforms to the full nutrition program, and the boys were brought up to weight before they were certified by the Employment Bureau. Notice the sturdy posture and general appearance of vigor in both boys at the right. (From Emerson, "Nutrition and Growth in Children," D. Appleton and Co., Publishers.)

the tissues and organs so that they will function better. A body which has been depleted by prolonged underfeeding will require building up in numerous respects. Not only should new deposits of FAT be laid down, but the muscles are in need of PROTEIN (rich in essential amino acids) for repair and enlargement, extra IRON is often needed for the blood, and even the bones may have been robbed of CALCIUM and PHOSPHORUS to meet the current insufficiency, so that there will be need for an increased supply of

these mineral elements. Reserve stores of VITAMINS are used up or lost from the body during semistarvation, and we know that an excess of vitamins in the diet is a help in the upbuilding processes necessary to repair after malnutrition. Constipation and poor intestinal hygiene are often chronic in malnourished individuals, so that a plentiful supply of fiber should be included in the corrective diet. For these reasons, we prefer to speak of the special diet that should be given in malnutrition as an **upbuilding** rather than a **fattening** diet, although the most striking effect of such diets is to cause the individual to put on weight through the deposition of fatty tissue. The important features of such a diet are described more fully below.

CHARACTERISTICS OF UPBUILDING DIETS

From the discussion in the above paragraph it should be apparent that the diet suitable for building up a body, which has suffered for some time from an insufficient food supply, should be planned so as to provide—

(1) A **high energy intake**—fuel in excess of body needs, which will be stored as fat.

(2) Abundant, or at least moderate, quantities of **protein** of **high quality.**

(3) An **abundant** supply of **mineral elements, vitamins** and fiber.

The first requirement is met by including in the diet **liberal** amounts of the **concentrated fuel foods,** especially foods rich in FATS, SUGARS and STARCHES, such as butter or margarine, cream, salad dressings, bacon, cereals, bread, sugar, cream soups, high-calorie desserts, legumes, nuts and dried fruits—in short all the list of foods forbidden to OVERWEIGHT individuals (p. 518). Fat meats, pastries, rich sauces and gravies should be used only in moderate amounts. There is danger of DIGESTIVE DISTURBANCES when so much concentrated food and so much fat is being taken, so that fats are best given in the more EASILY DIGESTED forms. Protein of high quality, for tissue building and repair, is provided by including liberal amounts of MILK, with EGGS and MEATS as freely as expense permits. Organ meats, such as liver, which are excellent sources of minerals and vitamins, should be taken frequently. Even though they may seem to increase the bulk of the diet undesirably, plenty of FRUITS and VEGETABLES should be included for their content of mineral elements, vitamins and fiber. Milk, eggs, and whole grain or "enriched" bread and cereals are also valuable sources of mineral salts and vitamins. While **high calorie content** is thus the **main objective** of the diet, care should be taken that it provides an ABUNDANCE OF ALL THE OTHER NUTRITIVE ESSENTIALS as well.

The diet should provide **energy in excess of body needs** by at least a 500–1000 calorie surplus. The calorie intake may be increased above body needs to the extent of $\frac{1}{3}$–$\frac{3}{4}$ of the energy required for maintenance, *e. g.*, a person who needs 2100 C. for maintenance should take approximately 2800–3500 C. when trying to put on weight. It is often necessary to force oneself to take food in excess of one's appetite, and sometimes to keep on taking it in spite of minor digestive disturbances. The food may be well utilized due to the effectiveness of the later stages of digestion, and nothing helps more toward greater nervous stability (hence less nervous indigestion) than taking on extra weight. It will be necessary that the CONCENTRATED FUEL FOODS (those with high calorie content) occupy a prominent place in the diet, in order to provide large amounts of energy without having the BULK of food uncomfortably large. Fatty foods, which are so high in fuel value, may be taken in considerable amounts, if well tolerated. It is easy to increase the energy intake considerably by such devices as an extra square of butter or fortified margarine at each meal (about 220 C.), liberal use of cream, bacon and salad dressings (1 tbsp. mayonnaise, 2 tbsp. thick cream, or $2\frac{1}{2}$ tbsp. whipped cream each furnish about 100 C.), 1 tbsp. salad oil after each meal (300 C.), and supplementary nourishment between meals or at bedtime.

The best foods to use for the **midmorning or midafternoon lunch** are MILK, raw EGGS and FRUIT JUICES. These can be served in many combinations, *e. g.*, plain cold milk enriched with a little cream, hot malted milk flavored with chocolate or cocoa, eggnog or beaten egg in fruit juice, fruit juice plain or with extra calories added in milk sugar or malt sugar (which are not very sweet). These foods are EASILY and QUICKLY DIGESTED, and hence are not so likely to upset digestion or spoil the appetite for meals. Many prefer to take more liberal meals and omit between-meal nourishment. In addition to being easily digested, the food provided should be as APPETIZING as possible. Salads, acid fruits and vegetables, meats, soups, relishes and tasty desserts are often helpful from this point of view.

An **illustrative menu** for a fattening, upbuilding diet is given on p. 544. The approximate number of calories furnished is included, as of interest in showing how rapidly the FUEL VALUE of the diet will mount when fats and concentrated starchy foods are included in any considerable quantities. The meals alone, as planned in this diet, will furnish 800 calories in excess of the energy needs of a sedentary man (2400 C.) without seeming unduly bulky. Supplementary nourishment between meals (as indicated) may be used to further increase the fuel intake by 440 C. More than 440 supplemental calories may be taken, if desired.

SAMPLE MENU FOR AN UPBUILDING DIET

(For Adult with Energy Requirement of About 2500 Calories)

	Calories (approximate)
BREAKFAST:	
Orange juice, 8 oz. glass	100
Wheatena with figs (2)	200
and cream ($\frac{3}{5}$ c. thin)	300
1 egg	79
Toast, whole wheat, 2 slices	130
with butter or margarine (1 tbsp.)	95
and jam ($1\frac{1}{2}$ tbsp.)	75
Coffee, sugar (1 tbsp.)	51
	1030
10.30 A. M.—1 glass milk (enriched with $\frac{1}{4}$ c. thin cream)	220
LUNCHEON:	
Creamed chicken on toast	250
Lettuce and tomato salad with mayonnaise dressing	150
Bread, whole wheat (1 slice) and butter or margarine (1 tbsp.)	170
Ice cream ($\frac{1}{2}$ c.)	200
Cocoa (1 c.)	200
	970
4.00 P. M.—1 glass malted or chocolate milk	220
DINNER:	
Cream vegetable soup	150
2 crackers	50
Roast lamb (liberal serving)	200
Baked potato (medium-sized)	100
with butter or margarine (1 tbsp.)	95
Peas (avg. serving) / Cream spinach (avg. serving)	100
Waldorf salad (med. serving)	200
Lemon meringue pie	300
	1195
Total	about 3600

GENERAL REGIMEN FOR INCREASING WEIGHT

The success of such a régime depends chiefly upon getting the individual to **take sufficient amounts** of a HIGH CALORIE DIET, while he simultaneously **cuts down muscular activity and tenseness** by taking EXTRA REST and RELAXATION. It is often best to keep such persons in bed for a time, especially those who are much rundown, or who find it very difficult to put on weight. Those who have little appetite, or who have developed fears that foods will cause digestive distress, must often force themselves to take food in excess of their natural desires at first. If this is done, the general condition will usually improve to such an extent that both the appetite

and digestion will return to normal. Rest is a very important factor, both in preventing the fuel intake from being burned up too rapidly and in securing better utilization of the food through improved digestion.

RAPID gains in weight should not be the main objective, as such gains are usually due solely to the deposition of FAT in the body while it is much to be desired that the muscle tissues also should be built up. MUSCLE DEVELOPMENT is favored by a more gradual gain in weight on a diet containing plenty of the best quality protein (milk, eggs and meat). In addition, MASSAGE to stimulate circulation in the muscles will be a help while the patient is in bed; when up and about, OUT-DOOR LIFE and some form of light but regular EXERCISE are the best aids to building up the muscle tissues (see suggestions for light exercise suitable for middle aged or obese persons, pp. 499 and 515). Cod liver oil (especially with malt extract and iron added), thiamine (vitamin B_1) tablets or some concentrated preparation of B-complex vitamins, citrus fruit or tomato juice are often helpful both to secure gain in weight, and to improve the appetite and general condition. Other PREPARATIONS RICH IN VITAMINS may be used. A steady gain in weight of about 2 lbs. per week is a moderate goal for which to strive.

The increase in HEALTH, ENDURANCE and NERVOUS STABILITY, which usually parallels the weight increase, is often amazing and is ample reward for persistence in an upbuilding regimen.

QUESTIONS AND PROBLEMS

1. What are the outward signs of good nutrition and a healthy body? In what respects does a malnourished individual differ from a well-nourished one, and how can the average person detect malnutrition? What tests can the doctor or nutritionists make to detect lesser grades of malnutrition?

2. How prevalent is severe malnutrition in the United States? How prevalent are lesser degrees of malnutrition? What are the disadvantages and dangers of malnutrition, in major degree and in minor degree? Why is it more prevalent among children?

3. What are the essential points in an effective diet for upbuilding of the body and putting on weight? What kind of a regimen will reinforce the good effects of the diet? What benefits may be expected from such a diet and regimen?

4. Plan a fattening and upbuilding diet that will furnish 3500 calories. Modify it to give the same fuel value for a person whose digestion is feeble and appetite poor.

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PART

6

APPENDIX

RECOMMENDED DIETARY ALLOWANCES, REVISED 1948*

(Amounts Per Day)

Food and Nutrition Board, National Research Council

	Calories.[1]	Protein.	Calcium.	Iron.	Vitamin A.	Thiamine.	Riboflavin.	Niacin (Nicotinic acid).	Ascorbic acid.	Vitamin D.
		grams	grams	mg.	I. U.[2]	mg.[3]	mg.[3]	mg.[3]	mg.	I. U.
Man (154 lb., 70 kg.)										
Sedentary	2400	70	1.0	12[4]	5000	1.2	1.8	12	75	[5]
Physically active	3000	70	1.0	12[4]	5000	1.5	1.8	15	75	[5]
With heavy work	4500	70	1.0	12[4]	5000	1.8	1.8	18	75	[5]
Woman (123 lb., 56 kg.)										
Sedentary	2000	60	1.0	12	5000	1.0	1.5	10	70	[5]
Moderately active	2400	60	1.0	12	5000	1.2	1.5	12	70	[5]
Very active	3000	60	1.0	12	5000	1.5	1.5	15	70	[5]
Pregnancy (latter half)	2400[6]	85	1.5	15	6000	1.5	2.5	15	100	400
Lactation	3000	100	2.0	15	8000	1.5	3.0	15	150	400
Children up to 12 yrs.:[7]										
Under 1 yr.[8]	110/2.2 lb. (1 kg.)	3.5/2.2 lb. (1 kg.)	1.0	6	1500	0.4	0.6	4	30	400
1–3 yrs. (29 lb., 13 kg.)	1200	40	1.0	7	2000	0.6	0.9	6	35	400
4–6 yrs. (42 lb., 19 kg.)	1600	50	1.0	8	2500	0.8	1.2	8	50	400
7–9 yrs. (58 lb., 26 kg.)	2000	60	1.0	10	3500	1.0	1.5	10	60	400
10–12 yrs. (78 lb., 35 kg.)	2500	70	1–2	12	4500	1.2	1.8	12	75	400

Children over 12 yrs.:[7]										
Girls, 13–15 yrs. (108 lb., 49 kg.)	2600	80	1.3	15	5000	1.3	2.0	13	80	400
16–20 yrs. (122 lb., 55 kg.)	2400	75	1.0	15	5000	1.2	1.8	12	80	400
Boys, 13–15 yrs. (108 lb., 49 kg.)	3200	85	1.4	15	5000	1.5	2.0	15	90	400
16–20 yrs. (141 lb., 64 kg.)	3800	100	1.4	15	6000	1.7	2.5	17	100	400

* Objectives toward which to aim in planning practical dietaries: The recommended allowances can be attained with a good variety of common foods which will also provide other minerals and vitamins, for which requirements are less well known.

[1] Calorie allowances must be adjusted up or down to meet specific needs. The calorie values in the table are therefore not applicable to all individuals but rather represent group averages. The proper calorie allowance is that which over an extended time will maintain body weight or rate of growth at the level most conducive to well-being.

[2] The allowance depends on the relative amounts of vitamin A and carotene. The allowances of the table are based on the premise that approximately two-thirds of the vitamin A value of the average diet in this country is contributed by carotene and that carotene has half or less than half the value of vitamin A.

[3] For adults (except pregnant and lactating women) receiving diets supplying 2,000 calories or less, such as reducing diets, the allowances of thiamine and niacin may be 1 mg., and 10 mg. respectively. The fact that figures are given for different calorie levels for thiamine and niacin does not imply that we can estimate the requirement of these factors within 500 calories, but they are added merely for simplicity of calculation. In the present revision, riboflavin allowances are based on body weight rather than caloric levels. Other members of the B complex also are required, though no values can be given. Foods supplying adequate thiamine, riboflavin, and niacin will tend to supply sufficient of the remaining B vitamins.

[4] There is evidence that the male adult needs little or no iron. The need will usually be provided for if the diet is satisfactory in other respects.

[5] The need for supplemental vitamin D by vigorous adults leading a normal life seems to be minimum. For persons working at night and for nuns and others whose habits shield them from sunlight, as well as for elderly persons, the ingestion of small amounts of vitamin D is desirable.

[6] During the latter part of pregnancy the allowance should increase approximately 20 per cent above the preceding level. The value of 2400 calories represents the allowance for pregnant, sedentary women.

[7] Allowances for children are based on the needs for the middle year in each group (as 2, 5, 8, etc.) and are for moderate activity and for average weight at the middle year of the age group.

[8] Needs for infants increase from month to month with size and activity. The amounts given are for approximately 6 to 8 months. The dietary requirements for some of the nutrients such as protein and calcium are less if derived largely from human milk.

FURTHER DIETARY RECOMMENDATIONS

Food and Nutrition Board, National Research Council

FAT. There is available little information concerning the human requirements for fat. Fat allowances must be based at present more on food habits than on physiological requirements. While a requirement for certain unsaturated fatty acids (the linoleic and arachidonic acids of natural fats) has been amply demonstrated with experimental animals, the human need for these fatty acids is not known. In spite of the paucity of information on this subject there are several factors which make it desirable that fat be included in the diet to the extent of at least 20 to 25 percent of the total calories and that the fat intake include "essential" unsaturated fatty acids to the extent of at least 1 percent of the total calories. At higher levels of caloric expenditure, *e. g.*, for a very active person consuming 4500 calories and for children and adolescent persons, it is desirable that 30 to 35 percent of the total calories be derived from fat. Since foodstuffs such as meat, milk, cheese, nuts, etc. contribute fat to the diet, it is necessary to use separated or "visible" fats such as butter, margarine, lard, or shortenings only to supply one-third to one-half of the amounts indicated.

COPPER. The requirement for copper for adults is about 1 to 2 mg. daily. Infants and children require approximately 0.05 mg. for each kilogram of body weight. The requirement for copper is approximately one-tenth that for iron. A good diet normally will supply sufficient copper.

IODINE. The requirement for iodine is small, probably about 0.002 to 0.004 mg. daily for each kilogram of body weight, or a total of 0.15 to 0.30 mg. daily for the adult. This need is met by the regular use of iodized salt; its use is especially important in ADOLESCENCE and PREGNANCY.

PHOSPHORUS. Available evidence indicates that the phosphorus allowances should be at least equal to those for calcium in the diets of children and of women during the latter part of pregnancy and during lactation. In the case of other adults the phosphorus allowances should be approximately 1.5 times those for calcium. In general it is safe to assume that if the calcium and protein needs are met through common foods, the phosphorus requirement also will be covered, because the common foods richest in calcium and protein are also the best sources of phosphorus.

VITAMIN K. The requirement for vitamin K usually is satisfied by any good diet except for the infant in utero and for the first few days after birth. Supplemental vitamin K is recommended during the last month of pregnancy. When it has not been given in this manner, it is recommended for the mother preceding delivery or for the baby immediately after birth.

SALT. The needs for salt and for water are closely interrelated. A liberal allowance of sodium chloride for the adult is 5 grams daily, except for some persons who sweat profusely. The average normal intake of salt is 10 to 15 grams daily, an amount which meets the salt requirements for a water intake up to 4 liters daily. When sweating is excessive, one additional gram of salt should be consumed for each liter of water in excess of 4 liters daily, With heavy work or in hot climates 20 to 30 grams daily may be consumed with meals and in drinking water. Even then, most persons do not need more salt than usually occurs in prepared foods. It has been shown that after acclimatization persons produce sweat that contains only about 0.5 gram to the liter in contrast with a content of 2 to 3 grams for sweat of the unacclimatized person. Consequently after acclimatization, need for increase of salt beyond that of ordinary food disappears.

WATER. A suitable allowance of water for adults is 2.5 liters daily in most instances. An ordinary standard for diverse persons is one milliliter for each calorie of food. Most of this quantity is contained in prepared foods. At work or in hot weather, requirements may reach 5 to 13 liters daily. Water should be allowed AD LIBITUM, since sensations of thirst usually serve as adequate guides to intake except for infants and sick persons.

NUTRITIVE VALUES OF FOODS

It should be understood that there is considerable variation in the composition of foods, especially in their vitamin content. Cooked foods are even more variable in composition than raw foods, due to variations in recipes, in fat and moisture content, and in amounts of vitamins lost in cooking. Hence, the figures given in the following table are mostly for raw foods, representing AVERAGES that are accepted as a fair standard. The sources of these figures are TABLES OF FOOD COMPOSITION IN TERMS OF ELEVEN NUTRIENTS, prepared by the Bureau of Human Nutrition and Home Economics, U. S. Dept. Agric., in cooperation with the National Research Council, U. S. DEPT. AGRIC. MISC. PUB. NO. 572, 1945. Figures for some cooked foods and prepared food products are taken from BOWES AND CHURCH, FOOD VALUES OF PORTIONS COMMONLY USED, 6th ed., 1946.

When computing the dietary intake of various nutrients from figures on raw foods, probable losses of minerals and vitamins in cooking should be taken into account. Minerals are lost principally through peeling and solubility in water, and losses vary with different vegetables and methods of cooking. Leafy vegetables tend to lose more minerals than root vegetables, and certain mineral salts are more soluble than others. In general, losses in boiled vegetables are 10 to 35 per cent for calcium and phosphorus, and 25 to 50 per cent for iron in foods.

Vitamin losses in storage, cooking and processing foods vary with the nature of the vitamin and of the food, with time and method of cooking. Although vitamin A and carotene are not water-soluble, they suffer gradual destruction when foods are cooked, especially when exposed to air. With water-soluble vitamins, as much as 50% may be in the cooking water or liquor of canned foods. Ascorbic acid, least stable of the vitamins, begins to be lost as soon as fruits and vegetables are harvested, is lost rapidly at higher temperatures in cooking and least when foods are refrigerated. Of the B vitamins, thiamine is least stable on heating, riboflavin and niacin more stable. Deductions recommended to cover average cooking losses are given in tabular form below.

Food.	Percentage of Raw Vitamin Value Lost in Cooking.				
	Vitamin A.	Thiamine.	Ribo-flavin.	Niacin.	Ascorbic acid.
Cereals		3–35			
Bread		10–15			
Eggs		15			
Meats					
Frying		15		15	
Broiling		30	15–20		
Roasting		40–50	(any method)	50 (stewing)	
Vegetables					
Leafy	20	25 (all kinds)	10–15 (all kinds)	15 (all kinds)	45
Green or yellow					40
Potatoes	7				20
Others	5				35
Fruits					30–40 (more if baked)

NUTRITIVE VALUES OF FOODS IN AVERAGE SERVINGS OR COMMON MEASURES (See Notes, p. 567)

Food.	Weight.	Approximate Measure.	Calories.	Protein.	Minerals.		Vitamins.				
					Calcium.	Iron.	A.	Thiamine, B_1.	Riboflavin, B_2.	Niacin.	Ascorbic acid, C.
	gm.			*gm.*	*mg.*	*mg.*	*I. U.*	*mg.*	*mg.*	*mg.*	*mg.*
Almonds, shelled	15	12–15 nuts	96	2.8	38	0.7		0.038	0.101	0.69	tr.
Apple, baked	115	1 large, 2 tbsp. sugar	200	0.5	9	0.5	135	0.030	0.023	0.20	2
Apple, fresh, E. P.	125	1 medium, $2^3/_4$ in. diam.	80	0.5	7	0.45	110	0.050	0.025	0.25	6
Applesauce, sweetened	100	$^1/_2$ cup, scant	80	0.2	4	0.2	60	0.010	0.010	tr.	1
Apricots, dried**	30	4-6 halves	88	1.6	26	1.5	2,230	0.003	0.048	0.99	4
Apricots, canned in sirup	100	6 halves	89	0.6	10	0.3	1,350	0.020	0.020	0.33	4
Apricots, fresh	100	2–3 medium	57	1.0	16	0.5	2,790	0.030	0.040	0.70	4
Artichoke, French, A. P.	200	1 large	60	2.8	39	1.0	190	0.095	0.020		9
Asparagus, canned, green	50	4–5 small tips	11	0.8	10	0.5	300	0.030	0.045	0.40	8
Asparagus, fresh, green	100	12 stalks, 4 in. long	26	2.2	22	1.0	1,000	0.160	0.170	1.20	20 (CK)
Avocado	100	$^1/_2$ of 4 in. pear	265	1.7	10	0.6	290	0.120	0.150	1.10	16
Bacon, medium, broiled	30	3 strips, 5 in. long, crisp	93	4.2	6	0.3		0.180	0.030	0.87	—
Bananas	100	1 medium	99	1.2	8	0.6	430	0.090	0.060	0.60	10
Beans, baked, canned, with pork	100	$^1/_2$ cup or 3 r. tbsp.	117	5.7	49	3.4		0.050	0.050	0.88	
Beans, lima, fresh	100	$^1/_2$ cup, steamed	131	7.5	63	2.3	280	0.250	0.140	0.90	32 (raw)
Beans, navy (or others), dried**	30	$^1/_2$ cup, cooked	105	6.6	44	3.1	—	0.180	0.072	0.63	—
Beans, soy, dried**	30	$^1/_2$ cup, cooked	105	10.5	68	2.4	33	0.342	0.093	0.63	tr.
Beans, string, green, canned	100	$^1/_2$ cup, drained	19	1.0	27	1.4	410	0.030	0.050	0.30	4

Beans, string, green, fresh..	100	½ cup, cooked	42	2.4	65	1.1	630	0.080	0.100	0.60	19
Beef, hamburger, raw.....	75	1 patty, 6 from 1 lb.	237	12.0	7	1.8		0.075	0.097	3.21	—
Beef, hamburger, cooked...	65	1 patty, 6 from 1 lb.	180	12.0	7	1.8		0.052	0.078	2.58	—
Beef, rib roast or steak, raw	100	1 slice, 4½ x 3 x ½ in.	277	17.4	10	2.6		0.110	0.140	4.70	—
Beet greens, raw ..	100	½ cup, steamed	33	2.0	*	3.2	6,700	0.050	0.170	0.30	34
Beets, raw	100	½–⅝ cup, diced, or 2 beets, 2 in. diam.	46	1.6	27	1.0	20	0.030	0.050	0.40	10
Biscuits, baking powder....	35	1 avg., 2 in. diam. or 2 small	93	2.5	21	0.6	24	0.088	0.075	0.67	—
Blackberries, fresh	100	⅔–1 cup, 4 r tbsp.	62	1.2	32	0.9	90	0.025	(0.070)	0.30	10
Blueberries, fresh	100	⅔ cup	68	0.6	16	0.8	280	0.030	0.070	0.30	16
Bread, white, unenriched...	25	1 slice, avg. household loaf, ½ in. thick	65	2.1	13	0.2		0.017	0.017	0.20	—
Bread, white, enriched ..	25	1 slice, avg. household loaf, ½ in. thick, min. standard	65	2.1	14	0.5		0.060	0.037	0.55	—
Bread, whole wheat, 60% .	28	1 slice, avg.	72	2.5	14	0.6		0.084	0.049	0.90	—
Bread, whole wheat, 100% .	28	1 slice, avg.	73	2.7	17	0.7		0.078	0.042	0.98	—
Broccoli, raw.....	100	2 stalks, 5 in. long or ¾ cup, steamed	37	3.3	130	1.3	3,500	0.090	0.210	0.90	118
Butter.....	13	1 tbsp. or 1 square, 1¼ x ½ in	95	0.08	2	0.03	330		0.001	0.01	—
Butter.....	10	1 pat, average	73	0.06	2	0.02	330		0.001	0.01	—
Brussels sprouts, raw.....	70	6 average	41	3.1	24	0.9	280	0.077	0.042	0.21	66
Cabbage, head, raw	50	½–¾ cup, shredded	15	0.7	23	0.3	40	0.035	0.030	0.15	26
Cabbage, head, raw	100	¾–1 cup, cooked	29	1.4	46	0.5	80	0.070	0.060	0.30	52
Cake, chocolate, 2 layer	100	1 pc., iced (1/12 of cake)	368	4.3	43	0.6	229	0.025	0.110	0.23	
Cake, cup, iced	52	1 medium	237	2.4	17	0.6	236	0.052	0.068	0.43	

* Calcium present is mostly in nonutilizable form.
** Dried fruits and legumes are given on dry weight basis, with approximate measure of this quantity after cooking.

NUTRITIVE VALUES OF FOODS IN AVERAGE SERVINGS OR COMMON MEASURES—*Continued*

Food.	Weight.	Approximate Measure.	Calories.	Protein.	Minerals.		Vitamins.				
					Calcium.	Iron.	A.	Thiamine, B_1.	Riboflavin, B_2.	Niacin.	Ascorbic acid, C.
	gm.			*gm.*	*mg.*	*mg.*	*I. U.*	*mg.*	*mg.*	*mg.*	*mg.*
Cake, plain, 2 layer	100	1 pc., iced (1/12 of cake)	325	4.0	20	0.8	276	0.077	0.108	0.67	
Cantaloupe (or muskmelon), E. P.	150	½ of 4½ in. melon, or ¾ cup of balls	35	0.9	26	0.6	5,130	0.090	0.060	1.20	50
Carrots, raw	100	1 large, or ¾ cup cubes	45	1.2	39	0.8	12,000	0.070	0.060	0.50	6
Cauliflower	70	4 rounded tbsp.	22	1.7	15	0.8	63	0.070	0.077	0.42	48
Celery, raw, bleached	50	2 stalks or hearts	11	0.7	25	0.3	5	0.015	0.020	0.15	4
Cereal, highly milled,** unenriched	30	¾ cup, cooked	108	3.5	11	1.1		0.018	0.030	0.22	—
Cereal, highly milled,** enriched	30	¾ cup, cooked	106	3.1	132	1.6		0.132	0.081	1.05	—
Cereal, whole wheat**	30	¾ cup, cooked	110	3.5	11	1.1		0.135	0.039	1.38	—
Chard, Swiss, raw	100	½ cup cooked, stalks and leaves	25	1.4	*	4.0	2.000	0.060	0.130	0.20	38
Cheese, American cheddar	20	slice 2 x 1 x 1½ in. or 2 tbsp. grated	79	4.8	175	0.1	348	0.008	0.100	0.04	—
Cheese, American cheddar	28.35	1 oz., average serving	112	6.8	247	0.2	493	0.011	0.142	0.06	—
Cheese, cottage	30	1 rounded tbsp.	30	5.8	25	0.2	9	0.006	0.087	0.03	—
Cheese, soft cream	28.35	2 tbsp. or ⅓ pkg., 2¾ x 2⅛ x ¾ in.	105	2.0	84	0.05	627	0.003	0.040	0.03	—
Cherries, canned in sirup, red	100	½ cup	117	0.6	11	0.3	430	0.030	0.020	0.08	3
Cherries, canned in sirup, white	100	½ cup, 12 large	86	0.6	11	0.3	12	0.030	0.020	0.08	3

Cherries, fresh, sweet	100	20–25 small, 15 large	80	1.1	17	0.5	15–1300	0.050	0.060	0.13	14
Chicken, broiler, fried	95	½ medium (margarine used)	176	20.6	12	(1.9)	(138)	(0.093)	(0.153)	(7.3)	—
Chicken, creamed	100	½ cup	172	15.6	81	2.1	161	0.047	0.170	2.20	—
Chicken, roasted	100	3 slices, 3½ x 2½ x 1¼ in.	192	28.3	22	2.7	+	0.092	0.214	10.20	—
Chicory or endive, curly	25	10 small leaves, avg. serving	6	0.4	19	0.4	900	0.015	0.050	0.09	3
Chocolate, bitter	28.35	1 oz., or 1 square	163	1.6	*27	0.7		tr.	0.068	0.31	
Chocolate, milk	43	1 bar, 5c, plain	238	3.2	86	1.1	64	0.044	0.219	0.14	
Chocolate, sweet	28.35	1 oz. plain, 1½ 5c bars	146	0.6	*	0.3		tr.	0.031	0.14	
Chocolate creams	13	1 avg. piece (35 to 1 lb.)	56	0.5	?	0.06			(0.007)	+	
Chocolate fudge	30	1 piece, 1¼ in. sq.	96	0.4	8	0.7	43	0.003	0.017	0.03	
Chocolate (beverage), half milk	172	1 cup, 2½ oz. milk	152	2.7	88	0.1	120	0.030	0.134	0.11	
Cocoa (beverage), half milk	166	1 cup, 2½ oz. milk	112	3.0	88	0.2	120	0.030	0.150	0.22	
Cod liver oil	3.7	1 tsp., U.S.P. min. standard	33	—			3,700 (plus 370 I. U. Vit. D)				
Collards, raw	100	½ cup, cooked	50	3.9	249	1.6	6,870	0.220	0.200	0.80	100
Cookies, molasses	15	1 large, 3½ in. diam.	68	0.9	11	0.5	14	0.035	0.026	0.34	
Cookies, plain sugar	20	1 med., 3 in. diam.	64	1.1	5	0.3	27	0.033	0.029	0.24	
Corn, sweet	100	1 med. ear	108	3.7	9	0.5	390 yellow 0 white	0.150	0.140	1.40	12
Corn, sweet, canned	100	½ cup	77	2.0	4	0.5	200 yellow tr. white	0.020	0.050	0.80	5

* Calcium present is mostly in nonutilizable form.
** Cereals are given on dry weight basis, with approximate measure of this quantity after cooking.

NUTRITIVE VALUES OF FOODS IN AVERAGE SERVINGS OR COMMON MEASURES — *Continued*

Food.	Weight.	Approximate Measure.	Calories.	Protein.	Minerals.		Vitamins.				
					Calcium.	Iron.	A.	Thiamine, B_1.	Riboflavin, B_2.	Niacin.	Ascorbic acid, C.
	gm.			*gm.*	*mg.*	*mg.*	*I. U.*	*mg.*	*mg.*	*mg.*	*mg.*
Corn bread	45	1 piece, 2 in. square	133	3.1	30	1.0	177	0.112	0.080	0.45	—
Cornflakes	28.35	$1\frac{1}{3}$ cups	107	2.2	1	0.5		0.120		0.60	—
Cornmeal, yellow, bolted**	30	$\frac{2}{3}$ cup, cooked	106	2.5	3	0.3	90	0.045	0.018	0.27	—
Cornmeal, white, enriched**	30	$\frac{2}{3}$ cup, cooked	106	2.5	33	0.9		0.135	0.081	1.08	—
Corn sirup, dark	20	1 tbsp.	59	—	12	0.6				0.04	—
Corn sirup, light	20	1 tbsp.	59	—	2	0.3	-			0.02	—
Crabmeat, canned	50	$\frac{3}{8}$ cup	50	8.4	66	1.0		0.112	0.075	1.08	—
Crackers, graham	10	1 cracker, $2\frac{1}{2}$ x $2\frac{3}{4}$ in.	42	0.8	2	0.2		0.030	0.012	0.15	—
Crackers, Ry-Krisp	6.5	1 piece, $1\frac{7}{8}$ x $3\frac{5}{8}$ in.	24	0.8	4	0.3		0.021	0.015	0.15	—
Crackers, saltines	4	1 cracker, 2 in. square	17	0.4	1	0.06		0.002			—
Cranberry Sauce	50	$2\frac{1}{2}$ tbsp., sweetened	105	0.05	5	0.15	5				(3)
Cream, thick	15	1 tbsp.	51	0.3	(11)	(0.01)	(248)	(0.004)	(0.020)	(0.02)	tr.
Cream, thick	60	$\frac{1}{4}$ cup or 4 tbsp.	204	1.2	(44)	(0.04)	(1,092)	(0.016)	(0.080)	(0.08)	tr.
Cream, thin, 20%	15	1 tbsp.	31	0.4	(14)	(0.01)	(125)	(0.005)	(0.021)	(0.02)	
Cream, thin, 20%	60	$\frac{1}{4}$ cup or 4 tbsp.	124	1.6	(56)	(0.04)	(500)	(0.020)	(0.084)	(0.08)	—
Cucumber, raw	50	$\frac{1}{2}$ med., 8 slices, pared	8	0.4	5	0.2		0.020	0.045	0.10	4
Custard, baked	158	1 serving, $\frac{5}{8}$ cup	186	8.3	161	1.0	551	0.085	0.313	0.15	
Dandelion greens, raw	100	$\frac{1}{2}$ cup, cooked	52	2.7	187	3.1	13,650	0.190	0.140	0.80	36
Dates	30	3–4, stoned	95	0.7	22	0.6	50	0.024	0.014	0.65	—

Doughnut, yeast	30	1 small, 3 in. diam.	123	2.0	13	0.4	51	0.067	0.056	0.50	—
Egg white	30	1 average	14	3.2	2	0.03	—		0.080	0.03	—
Egg yolk	16	1 average	57	2.6	24	1.2	514	0.051	0.083	0.01	—
Eggs, whole, raw	50	1 medium average	79	6.4	27	1.4	570	0.060	0.170	0.05	—
Eggplant	100	½ cup, cooked	28	1.1	15	0.4	30	0.070	0.060	0.80	5
Escarole	50	2 large leaves	12	0.8	37	0.9	5,000	0.025	0.100	0.19	8
Figs, dried	30	2 small	90	1.2	67	0.9	21	0.039	0.032	0.52	—
Figs, fresh	100	4 large	88	1.4	50	0.7	75	0.090	0.080	0.60	2
Fruit cocktail, canned	120	½ cup	78	0.4	9	0.4	160	0.010	0.010	0.04	2
Fish, cooked, average: baked or broiled	100	1 average serving	208	24.0	26	1.3		0.054	0.056	2.94	—
	60	1 small serving	125	14.4	16	0.8		0.032	0.034	1.6	—
boiled or steamed, leaner fish	100	1 avg. serving, bass, cod, haddock, halibut	102	21.0	23	1.2		0.054	0.056	2.94	—
boiled or steamed, leaner fish	60	1 small serving, same types	61	12.6	14	0.7		0.032	0.034	1.76	—
boiled or steamed, fatter fish only	100	1 serving, mackerel, tuna, etc.	185	21.5	23	1.2		0.054	0.056	2.94	—
boiled or steamed, fatter fish only	60	1 small serving, same types	110	12.9	14	0.7		0.032	0.034	1.76	—
fried in flour, meal or batter	100	1 serving, most fish, med. fat absorption	207	19.5	21	1.1		0.054	0.056	2.94	—
fried in flour, meal or batter	60	1 small serving, most fish, med. fat absorption	124	11.7	13	0.7		0.032	0.034	1.76	—
[illegible]	120	1 cup	430	10.7	22	1.6		0.180	0.184	1.08	—

** Weight on dry basis, with approximate measure after cooking.

NUTRITIVE VALUES OF FOODS IN AVERAGE SERVINGS OR COMMON MEASURES—*Continued*

Food.	Weight.	Approximate Measure.	Calories.	Protein.	Minerals.		Vitamins.				
					Calcium.	Iron.	A.	Thiamine, B_1.	Riboflavin, B_2.	Niacin.	Ascorbic acid, C.
	gm.			*gm.*	*mg.*	*mg.*	*I. U.*	*mg.*	*mg.*	*mg.*	*mg.*
Flour, rye, whole grain	120	1 cup	432	13.4	73	5.8		0.564	0.252	2.04	—
Flour, wheat, patent	112	1 cup, unenriched, sifted once	397	12.1	21	0.8		0.078	0.034	0.90	—
Flour, wheat, enriched	112	1 cup, sifted once	397	12.1	21	3.2		0.493	0.296	3.92	—
Flour, wheat, whole grain	130	1 cup, unsifted	467	16.9	49	4.9		0.728	0.156	7.28	—
Grapefruit, E. P.	100	½ med., 4 in. diam.	44	0.5	17	0.3	tr.	0.040	0.020	0.20	40
Grapefruit juice, canned	180	small glass (6 oz.), unsweetened	85	0.7	14	0.7	tr.	0.054	0.036	0.39	63
Grapefruit and orange juice, canned	180	small glass (6 oz.)	94	1.1	36	0.7	72	0.072	0.036	0.36	68
Grapes, American	100	22–24, avg.-sized	78	1.4	17	0.6	80	0.050	0.030	0.40	4
Grapes, Malaga or Tokay	100	22 average-sized	74	0.8	10	0.6	80	0.030	0.040		2
Griddle cakes, white flour	50	1 med., 4 in. diam.	76	2.4	32	0.4	110	0.062	0.078	0.42	—
Honey, strained	20	1 tbsp.	64	0.1	1	0.2		tr.	0.008	0.04	1
Honeydew melon	100	¼ of 5 in. melon	36	0.6	17	0.4	10	0.050		0.30	20
Ice cream, plain, vanilla	100	⅙ of a quart	210	4.0	132	0.1	540	0.040	0.190	0.10	tr.
Ice cream, chocolate	140	1 avg. serving, some cream in recipe	278	4.1	124	0.3	552	0.040	0.196	0.19	1
Ice, orange, water	130	1 serving, ½ cup	147	—	13	0.2	101	0.040	0.014	0.11	25
Jam, avg. coml	20	1 tbsp. level or heaping tsp.	58	0.1	4	0.06	2	0.002	0.004	0.03	tr.
Jellies, avg. coml	20	1 tbsp. level or heaping tsp.	52	0.04	3	0.06	2	0.002	0.004	0.03	tr.

Jello, plain	65	1 serving (5 to pkg.)	67	1.6							
Junket	135	⅛ of 1 quart milk	110	4.2	144	0.1	195	0.047	0.207	0.12	1
Kale, raw	100	½ cup, cooked	50	3.9	225	2.2	7,540	0.120	0.350	0.80	115
Kidney, stewed	100	½ cup, cubed	114	16.7	16	5.7	783	0.160	1.411	3.77	?
Kohlrabi, raw	100	½ to ⅔ cup, diced	36	2.1	78	0.7		0.050		0.27	60
Lamb, rib chop, cooked	105	1 chop, 1 in. thick, or 2 small	261	17.9	12	2.6		0.180	0.224	4.96	—
Lamb, leg, roasted	100	3 slices, 3 x 2¾ x ⅛ in.	162	12.5	7	2.0		0.086	0.155	2.87	—
Lard	11	1 tbsp.	99	—			tr.				
Lemon	100	1 med. large	44	0.9	14	0.1		0.040	tr.	0.10	45
Lemon juice, fresh	15	1 tbsp.	5	0.06	(2)	(0.01)		0.006		0.01	7
Lemon juice, fresh	100	3½ oz., ½ cup scant	33	0.7	(14)	(0.1)		0.040	tr.	0.08	45
Lentils, dried**	30	½ cup, cooked	104	7.4	29	2.5	tr.	0.135	0.057	0.9	
Lettuce, head	57	1/5 of large head	11	0.6	11	0.3	308	0.034	0.040	0.11	6
Lettuce, loose green leaf	20	2 large leaves	4	0.2	12	0.2	324	0.012	0.014	0.04	4
Liver, calf, cooked	80	2 slices, 2¾ x 2 x ¾ in.	166	19.0	11	5.4	10,000	0.161	2.905	12.75	?
Liver, pork, cooked	80	2 slices, 2¾ x 2 x ¾ in.	159	19.7	8	12.5	10,000	0.442	2.295	11.18	?
Lobster, canned	60	½ cup scant	52	11.0	37	0.8		0.070	0.060		—
Loganberries, canned, juice pack	100	½ cup scant	55	0.1	19	1.5		0.020	0.042	0.18	33
Loganberries, fresh	100	¾ cup	69	1.0	27	2.1		0.033	0.079	0.30	35
Macaroni, plain**	30	¾–1 cup, cooked	108	3.9	7	0.4		0.039	0.024	0.63	—
Macaroni, cooked, with cheese	220	1 cup	308	11.9	272	0.6	568	0.110	0.309	0.92	
Margarine, fortified	13	1 tbsp.	95	0.08	tr.	0.03	258–429*				

* Fortified margarine contains from 9,000 to 15,000 I. U. of vitamin A per pound.
** Weight on dry basis, approximate measure after cooking.

NUTRITIVE VALUES OF FOODS IN AVERAGE SERVINGS OR COMMON MEASURES—*Continued*

Food.	Weight.	Approximate Measure.	Calories.	Protein.	Minerals.		Vitamins.				
					Calcium.	Iron.	A.	Thiamine, B_1.	Riboflavin, B_2.	Niacin.	Ascorbic acid, C.
	gm.			*gm.*	*mg.*	*mg.*	*I. U.*	*mg.*	*mg.*	*mg.*	*mg.*
Meat, avg. cooked: lean, medium done	100	3½ oz., 1 serving	174	30.0	17	4.5					
med. fat, med. done	100	3½ oz., 1 serving	270	27.0	15	4.1					
fat, medium done	100	3½ oz., 1 serving	358	22.0	13	3.3					

Vitamin losses in cooked meats vary with method of cooking. Thiamine losses average 30% for broiling, 40% for roasting, and 15% for frying. A loss of 15–20% for riboflavin is a fair average for most cooking methods. Niacin losses range from 15% for frying to 50% for stewing. For vitamin values in raw meats see individual meats listed, beef, lamb, etc.

Milk, condensed, sweetened	15	1 tbsp.	49	1.2	41	(0.03)	(65)	(0.008)	(0.059)	(0.03)	
Milk, dried, whole	14	1 tbsp.	70	3.6	134	0.08	188	0.042	0.200	0.10	1
Milk, dried, skim	14	1 tbsp.	51	5.0	184	0.08	(6)	0.048	0.278	0.15	1
Milk, evaporated	16	1 tbsp.	22	1.1	39	0.03	64	0.008	0.058	0.03	tr.
Milk, fresh, whole	240	8 oz., 1 cup or full glass, or ½ pint	165	8.2	283	0.17	(384)	0.096	0.408	0.24	2
Milk, skim (or buttermilk)	240	8 oz., 1 cup or full glass	84	8.4	(283)	(0.17)	(tr.)	(0.096)	(0.432)	(0.24)	(2)
Molasses, medium	142	½ cup	341	—	387	9.5		0.113	0.227	3.97	—
Muffins, bran	35	1 medium	92	2.5	35	1.3	64	0.074	0.088	1.54	—
Muffins, cornmeal	45	1 medium	123	3.8	33	0.7	132	0.090	0.101	0.59	—
Muffins, white flour	40	1 medium (12 from 2 cups flour)	111	3.3	29	0.7	117	0.096	0.098	0.69	—
Mustard, greens, raw	100	½ cup, cooked	28	2.3	220	2.9	6,460	0.090	0.200	0.80	102
Oatmeal**	30	⅔ cup, cooked	119	4.3	16	1.6		0.165	0.042	0.33	—
Oil, vegetable (corn, cotton-seed, or olive)	11	1 tbsp.	99	—							
Olives, green or ripe	10	1 medium or 2 small	15	0.2	10	0.2	34–42	tr.			

Onions, green, raw	10	1 medium-sized onion	5	0.1	3	0.06	500	0.003	0.012	0.01	4
Onions, mature, raw	100	1 large, or 2–3 small	49	1.4	32	0.5	50	0.030	0.020	0.10	9
Orange, whole	125	1 medium	63	1.1	41	0.5	237	0.100	0.037	0.25	61
Orange juice, fresh	180	6 oz., small glass	72	1.6	59	0.7	342	0.144	0.054	0.36	88
Oysters, raw	100	4–6 medium, or $\frac{1}{3}$ cup solids with liquor	50	6.0	68	7.1		0.180	0.230	1.20	2
Parsley, fresh, raw	1	1 sprig, or 1 tsp. chopped	1	0.04	2	0.04	180		0.003		1
Parsnips, raw	100	$\frac{1}{2}$ large	83	1.5	57	0.7	—	0.110	0.090	0.20	18
Peaches, yellow, canned in syrup	100	2 halves, 1 tbsp. juice	75	0.4	5	0.4	450	0.010	0.020	0.70	4
Peaches, yellow, dried, stewed	95	3 halves, 2 tbsp. juice	200	1.5	22	3.4	1,625	0.005	0.100	2.70	?
Peaches, yellow, fresh	100	1 med. large	51	0.5	8	0.6	880	0.020	0.050	0.90	8
Peanut butter	15	1 tbsp. scant	93	3.9	11	0.3		0.030	0.024	2.43	—
Peanuts, roasted, E. P.	15	16–17 nuts, no skins	89	4.0	11	0.3		0.045	0.024	2.43	—
Pears, canned in sirup	100	2 halves, 1 tbsp. juice	75	0.2	8	0.2	tr.	0.010	0.020	0.10	2
Pears, fresh	100	1 medium	70	0.7	13	0.3	20	0.020	0.040	0.10	4
Pecans	15	12 halves	113	1.4	11	0.4	8	0.108	0.017	0.13	tr.
Peppers, green, raw	100	1 medium shell, 4 in. long	29	1.2	11	0.4	630	0.070	0.040	0.40	120
Pie, apple		$\frac{1}{8}$ of med.-sized pie	266	2.6	11	0.6	116	0.053	0.030	0.42	1
Pie, custard		$\frac{1}{6}$ of med.-sized pie	328	7.4	111	0.9	413	0.071	0.227	0.24	
Pie, mince		$\frac{1}{6}$ of med.-sized pie	353	6.2	19	1.4	113	0.029	0.084	0.71	?
Pineapple, canned in sirup	100	1 slice, $\frac{3}{4}$ in. thick	87	0.4	10	0.6	80	0.070	0.020	0.20	9
Pineapple, fresh	100	1 slice, $\frac{3}{4}$ in thick, or $\frac{2}{3}$ cup diced	58	0.4	16	0.3	130	0.080	0.020	0.20	24
Pineapple juice, canned	180	6 oz., small glass	97	0.5	27	0.9	144	0.090	0.036	0.36	16

** Weight on dry basis, approximate measure after cooking.

NUTRITIVE VALUES OF FOODS IN AVERAGE SERVINGS OR COMMON MEASURES—*Continued*

Food.	Weight.	Approximate Measure.	Calories.	Protein.	Minerals.		Vitamins.				
					Calcium.	Iron.	A.	Thiamine, B_1.	Riboflavin, B_2.	Niacin.	Ascorbic acid, C.
	gm.			*gm.*	*mg.*	*mg.*	*I. U.*	*mg.*	*mg.*	*mg.*	*mg.*
Plums, fresh	100	3 medium	56	0.7	17	0.5	350	0.150	(0.030)	0.60	5
Pork, chop, shoulder, fried	70	1 chop, med., some fat	297	13.4	9	2.0		0.722	0.144	3.10	—
Pork, loin, roasted	100	2 pieces, $2\frac{1}{2}$ x $2\frac{1}{2}$ x $\frac{1}{4}$ in.	286	21.3	13	3.3		0.811	0.170	3.52	—
Potatoes, white, cooked in skin	125	1 medium-sized	107	2.5	14	0.9	25	0.133	0.046	0.13	14
Prunes, dried, stewed	100	4–5 med., 2 tbsp. juice	169	1.1	27	1.9	945	0.050	0.080	0.85	?
Pudding, cornstarch, caramel	140	1 serving, $\frac{1}{2}$ cup	196	4.3	161	0.7	195	0.047	0.207	0.12	
Pudding, rice with raisins		1 serving, $\frac{1}{2}$ cup	250	5.8	151	0.5	199	0.068	0.219	0.42	
Pudding, tapioca		1 serving, $\frac{1}{2}$ cup	142	4.9	104	0.6	316	0.052	0.193	0.96	
Pumpkin	100	$\frac{1}{2}$ cup, scant	38	1.0	20	0.7	3,400	0.020	0.060	0.50	—
Radishes, red, raw	10	1 radish, 1 in. diam.	2	0.1	4	0.1	3	0.004	0.004	0.01	2
Raisins, seeded	30	$\frac{1}{4}$ cup	90	0.7	23	1.0	15	0.045	0.024	0.15	tr.
Raspberries, canned in sirup	100	½ cup, scant	118	0.6	24	0.5	100	0.020	0.040		10
Raspberries, fresh, red	100	¾–1 cup	67	1.1	40	0.9	150	0.030	0.070		25
Rhubarb, stewed	120	½ cup, sweetened	174	0.5	†	0.5	24	0.007		0.08	4
Rice, white**	30	¾ cup, cooked	105	2.3	3	0.2		0.015	0.009	0.42	—
Rice, wild**	30	¾ cup, cooked	109	4.1				0.141	0.189	1.82	
Rolls, white, hard	35	1 avg., no milk or butter	106	2.9	20	0.6	—	0.084	0.053	0.77	—
Rolls, white, soft	35	1 cloverleaf	112	3.0	6	0.8	32	0.113	0.075	0.87	—

Salad dressing, French	15	1 tbsp.	67	0.1	1	0.3					
Salad dressing, mayonnaise	14	1 tbsp.	101	0.2	2	0.06	29	0.006	0.006	tr.	—
Salad dressing, Russian	14	1 tbsp.	78	0.3	2	0.2	124	0.011	0.009	0.19	tr.
Salad dressing, coml., avg.	14	1 tbsp.	55	0.1	1	0.6	20	0.003	0.004	tr.	—
Salmon, canned, pink	100	1 cup, scant	167	20.2	194*	1.3	80	0.030	0.180	6.50	—
Salmon, canned, red	100	1 cup, scant	138	20.5	194*	1.3	325	0.030	0.225	6.50	—
Sausages:											
Bologna	30	1 slice, 4½ diam. x ⅛ in.	65	4.4	3	0.7		0.093	0.090	0.90	—
Frankfurter, boiled	60	1 avg., 5½ in. long	121	9.1	5	1.4		0.111	0.135	1.23	—
liver	30	1 slice, 4 in. diam. x ¼ in.	78	5.0	3	1.6	(1,725)	0.051	0.336	1.40	—
pork, patties, cooked	40	1 patty, 2 in. diam. (7 to 1 lb.)	186	7.0	4	1.0		0.195	0.081	1.17	—
Sherbet, lemon, milk	130	1 small serving, ½ cup	247	4.6	147	0.1	195	0.055	0.217	0.14	8
Shrimps, canned	60	5–8 shrimps	49	10.7	45	1.2	36	0.006	0.018	1.14	—
Sirup, table, mixed	20	1 tbsp.	59	—	9	0.8			0.002	0.02	—
Spinach, fresh, raw	100	⅗ cup, cooked	25	2.3	*	3.0	9,420	0.120	0.240	0.70	59
Squash, summer, avg., raw	100	½ cup, cooked	19	0.6	15	0.4	260	0.040	0.050	1.10	17
Squash, winter, raw	100	½ cup, cooked (yellow)	44	1.5	19	0.6	4,950	0.050	0.080	0.60	8
Strawberries, fresh	100	10 large	41	0.8	28	0.8	60	0.030	0.070	0.50	60
Sugar, brown, dark	90	½ cup	344	—	68	2.3	—	—	—	—	—
Sugar, white, gran.	105	½ cup	420	—	—	0.1	—	—	—	—	—
Sugar, white, gran.	13	1 tbsp. (3 tsp.)	52	—	—	tr	—	—	—	—	—
Sugar, white, loaf	6–8	1 cube or domino	24–32	—	—	tr	—	—	—	—	—
Sweet potatoes, baked	170	1 large	213	3.1	51	1.2	8,287	0.143	0.089	1.13	28

* Calcium content in canned salmon includes bone. Calcium in spinach is not utilizable.
** Weight on dry basis, approximate measure after cooking.
† Oxalic acid in rhubarb tends to increase urinary acidity and to render calcium unavailable.

NUTRITIVE VALUES OF FOODS IN AVERAGE SERVINGS OR COMMON MEASURES—*Concluded*

Food.	Weight.	Approximate Measure.	Calories.	Protein.	Minerals.		Vitamins.				
					Calcium.	Iron.	A.	Thiamine, B_1.	Riboflavin, B_2.	Niacin.	Ascorbic acid C.
	gm.			*gm.*	*mg.*	*mg.*	*I. U.*	*mg.*	*mg.*	*mg.*	*mg.*
Sweet potatoes, candied....	150	1 medium, 2 halves	275	3.1	52	1.3	5,482	0.143	0.089	1.13	19
Tomatoes, canned.....	100	½ cup	21	1.0	(11)	(0.6)	1,050	0.050	0.030	0.70	16
Tomatoes, fresh.....	100	1 medium	23	1.0	11	0.6	1,100	0.060	0.040	0.60	23
Tomato juice, canned.....	180	6 oz., small glass	42	1.8	12	0.7	1,890	0.090	0.054	1.26	29
Tongue, beef.....	100	3 slices, 3 x 2⅛ x ¼ in.	202	16.4	30	6.9		0.220	0.270	5.00	—
Turkey, cooked, avg. lean..	100	2 slices, 4¼ x 2½ x ¼ in.	185	35.3	20	5.3		0.162	0.214	6.99	—
Tuna fish, canned.....	100	¾ cup	217	27.7	34	1.7	70	0.040	0.130	10.60	—
Turnip greens, raw.....	100	½ cup, cooked	37	2.9	259	2.4	9,540	0.100	0.560	0.80	136
Turnips, rutabagas, raw....	100	½ cup, cooked (yellow)	41	1.1	55	0.4	330	0.060	0.060	0.50	36
Turnips, white, raw.....	100	½ cup cubes, cooked	35	1.1	34	0.3	tr.	0.035	0.051	0.33	16
Veal, cutlet, breaded.....	122	1 chop, 4 x 2¼ x ½ in.	284	24.8	23	4.1	114	0.168	0.350	7.15	—
Veal, leg, roasted.....	105	1½ slices, 3 x 2¾ x ⅛ in.	186	28.6	16	4.3		0.153	0.343	7.56	—
Waffles.....	60	1 waffle, 6 in. diam.	224	5.1	59	1.0	167	0.130	0.166	0.83	—
Walnuts, English.....	15	8–15 halves, 1¼ tbsp. chopped	106	2.3	12	0.3	9	0.077	0.020	0.18	tr.
Watercress, raw.....	5	5 avg. sprigs	2	0.1	8	0.15	150	0.005	0.011		3
Watermelon, E. P.....	100	½ cup, cubes or balls	31	0.5	7	0.2	590	0.050	0.050	0.20	6
Watermelon, E. P.....	600	1 slice, 6 in. diam. x 1½ in. thick	188	3.0	42	1.2	3,540	0.300	0.300	1.20	36
Wheat germ.....	10	1 tbsp.	39	2.5	8	0.8		0.205	0.080	0.46	

Wheat, shredded.....	30	1 biscuit, or ½ cup ¾ in. squares	110	3.1	(11)	(1.1)		0.060	0.042	1.26	—
Yeast, bakers' moist.....	12	1 cake, compressed	13	1.6	3	0.6	—	0.054	0.248	3.38	
Yeast, dried, brewers'.....	10	1 tbsp.	35	4.6	11	1.8	—	0.969	0.545	3.62	
Yeast, brewers', tablets....		1 tablet					—	0.060	0.020	0.15	—

NOTES

Since the National Research Council's recommended allowances for vitamins are given in milligrams, vitamin content of foods has been stated in these units except vitamin A, which is expressed in International Units. If desired to convert milligrams to micrograms (whole numbers), simply move decimal point three places to right, *e. g.*, 0.100 milligram = 100 micrograms.

Abbreviations used in the preceding table: E. P. edible portion; A. P., as purchased; (CK), cooked + indicates food contains some of vitamin in question; − indicates food contains none of vitamin in question; ? indicates questionable vitamin content.

100-CALORIE PORTIONS OF COMMON FOODS

Food.	Size of 100-calorie portion.
Breads:	
Boston brown	1 slice, 3 in. diam., $\frac{3}{4}$ in. thick
Corn	Piece, 2 in. square x $1\frac{1}{2}$ in. thick
Raisin	$1\frac{1}{2}$ average slices
Rye, light	$1\frac{1}{3}$ average slices
Toast, melba	5 pieces, $3\frac{1}{2}$ x $1\frac{1}{2}$ x $\frac{1}{4}$ in.
Wheat, white	$1\frac{1}{2}$ average slices (3 slices, 200 C.)
whole grain	$1\frac{1}{3}$ average slices (4 slices, 300 C.)
Quick breads:	
Biscuits, baking powder	1 average ($2\frac{1}{4}$ in. diam.) or 2 small
Griddle cakes	$1\frac{1}{3}$ cakes, 4 in. diam. (4 cakes, 300 C.)
Muffins	1 average ($2\frac{1}{2}$ in. diam.)
Rolls	1 average
Waffles	$\frac{1}{2}$ waffle, 6 in. diam.
Crackers:	
Arrowroot	5 crackers
Cheese	$4\frac{1}{2}$ crackers (2 in. diam.)
Graham	$2\frac{1}{2}$ crackers ($2\frac{1}{2}$ x $2\frac{3}{4}$ in.)
Oyster	25 crackers
Ry-krisp	4 crackers ($1\frac{5}{8}$ x $3\frac{7}{8}$ in.)
Saltines	6 crackers (2 in. square)
Soda	4 crackers ($2\frac{1}{2}$ x $2\frac{3}{4}$ in.)
Triscuit	4 triscuit (2 in. square)
Zwieback	3 pieces
Breakfast cereals:	
Cooked,	
Cornmeal, Oatmeal	about $\frac{2}{3}$ cup
Farina (cream of wheat), Wheat, Ralston's, flaked, cracked, Rice, white or brown	about $\frac{3}{4}$ cup
Ready to serve,	
Corn flakes	$1\frac{1}{3}$ cups
Grapenuts	$\frac{3}{8}$ cup or 5 level tbsp.
Rice, Krispies	1 cup
puffed	2 cups
Wheat, germ	$2\frac{1}{2}$ tbsp.
puffed	$2\frac{1}{2}$ cups
shredded	1 biscuit
Macaroni, spaghetti, or noodles:	
Plain	$\frac{1}{4}$ cup, cooked
With cheese	$\frac{3}{8}$ cup

Food.	Size of 100-calorie portion.
Cakes, cookies, pies, etc.:	
Cake, plain	1 cupcake or piece 2 in. square x 1 in. thick (Icing, nuts, fruits, etc. extra)
chocolate layer, iced	¼ of average serving
sponge or angel	1 medium piece (1/12 of cake)
Cookies, crisp, thin	3½ small cookies
soft, thick	1½ medium, 3 in. diam.
Gingerbread	Piece, 2 in. square x 1 in. thick
Lady fingers	2–4
Macaroons	1 large or 2 small
Doughnuts	½, average sized
Pies, with top crust	slice, 1½ in. at circumference (about ⅛ of average serving)
without top crust	slice, 2 in. at circumference (about ⅙ of average serving)
Puddings, ice cream, and other desserts:	
Cup custard, baked Plain blanc mange	½ of average serving, ¼–⅓ cup
Chocolate blanc mange	⅓ of average serving, scant ¼ cup
Junket Jello, plain	1 average serving, ⅔–1 cup
Cereal puddings (rice, bread, tapioca, plain)	⅔ average serving (⅓–½ cup)
Ice cream, plain	Small scoop, or ¼ cup (less if rich)
Sundaes, caramel or chocolate sauce	Scant ⅓ average serving
Sherbets and ices	Small serving, about ⅓ cup
Candies:	
Plain hard candies, Peppermints Molasses candy Lemon drops, etc.	about 1 oz.
Caramels, plain	2½ medium pieces
chocolate nut	1 in. cube (approx.)
Chocolate, creams	2 medium-sized
fudge	Piece, 1½ x 1 x ¾ in.
mints	2 small or 1 medium
Milk chocolate	Piece 2¼ x 1 x ⅛ in., about ½ of 5c. bar
Sirup	2 tbsp. (scant)
Honey, strained	1½ tbsp.
Jam or jelly	2 level tbsp.
Sugar, white	5 tsp. slightly rounded, or 2 level tbsp., or 4 dominos
Meats:	
Lean meats, medium done, about	2 oz. or piece 3 x 2 x ½ in. (lean part of small lamb chop about 1 oz.)
Fatty meats, medium done, about	1 oz. or ⅓ medium serving

Food.	Size of 100-calorie portion.
Bacon, broiled, crisp	3 strips (7 in. long raw)
Chicken, fried or creamed	⅓ cup, creamed, or ⅓ med. broiler, fried (approx.)
Liver, fried	⅔ of average serving (about 2 oz.)
Sausages	1 Frankfurt or 1 link pork sausage (3 in. long)
Fish and shellfish:	
Leaner fish, boiled or steamed	3½ oz., average serving
baked or broiled	2 oz., or small serving
Fatter fish, boiled or steamed	2 oz., or small serving
Most fried fish, about	1½ oz., or ½ average serving
Salmon, canned	½ cup
Tuna fish, canned	⅓ cup
Sardines	5 medium (1½ oz.)
Lobster or crabmeat, canned	¾ cup (3½ oz.)
Shrimps, canned	10–16 (4 oz.)
Oysters	6–12 oysters or ⅔ cup edible portion
Eggs, whole	1 large (1⅓ medium)
scrambled	1 medium egg, or ⅓ cup
omelet	1 egg, or 4 in. sector x 3¼ x 1 in.
Milk and milk products:	
Whole milk (1 glass, 165 calories)	⅝ cup (5 oz.)
Skimmed milk or buttermilk	1¼ cup (10 oz.)
Cream, thin	¼ cup or 4 tbsp.
thick	2 tbsp.
whipped	2 tbsp.
Condensed milk (sweetened)	2 tbsp.
Evaporated milk (unsweetened)	4½ tbsp.
Dried whole milk (or malted milk)	3 tbsp. (scant)
Dried skim milk	4 tbsp.
Cheese, American (cheddar)	1 oz., or 1⅛ in. cube (3 tbsp. grated)
cottage	½ cup or 6 level tbsp.
cream	⅓ package (2¾ x 2⅛ x ¾ in.)
Fats:	
Butter	1 tbsp. or 1⅓ avg. square (4 squares 300 C.)
Margarines	1 tbsp. (level)
Oils (corn, cottonseed, olive, etc.) / Shortenings (lard or other clear fat)	1 tbsp. (level)
Nuts:	
Almonds	12–15 nuts (½ oz.)
Brazil nuts	2 medium

Food.	Size of 100-calorie portion.
Filberts (hazelnuts)	12 medium
Peanut butter	1 tbsp.
Peanuts, roasted	16–17 nuts
Pecans	12 halves
Walnuts, English	8–12 halves or 1¼ tbsp. chopped
Coconut, desiccated	2¼ tbsp.
Cocoa, beverage	⅜–⅝ cup (depending on richness and sweetness)
Chocolate, beverage	¼–½ cup (scant)
Fruits, dried:	
Dates	3–4
Figs	1½–2
Raisins (and currants)	¼ cup or 2½ tbsp. (seedless)
Prunes	3–4 medium
Apricots	5–6 halves
Fruits, fresh:	
Apples	1 large, 3¼ in. diam.
Avocados	⅕ of 4 in. pear
Bananas	1 medium
Berries (or stoned sour cherries)	about 1 cup
Strawberries	25 large
Grapefruit	1 medium
Grapes, Concord	about 32
Malaga	about 26
Oranges	2 small
Peaches	2 medium large
Pears	1½ medium
Plums (or fresh apricots)	4–6 medium, 3–4 large
Olives, green	7 medium
ripe	6 medium
Pineapple	2 slices, ¾ in. thick or 1 cup diced
Cantaloupe	1 melon, 5 in. diam.
Watermelon	Slice, 6 in. diam., ¾ in. thick
Fruits, stewed or canned	⅓–½ cup (depending on amount of sugar in fruit or added)
Fruit juices:	
Tomato	1⅓ cup (14 oz.)
Grapefruit or lemon, Orange, Raspberry or loganberry	about 1 cup or glass (8 oz.)
Pineapple	¾ cup (6 oz.)
Prune, Grape	about ⅝ cup, 4½ oz.

Food.	Size of 100-calorie portion.
Vegetables (exclusive of butter or sauces):	
Potatoes, white, baked or boiled	1 medium
mashed or creamed	¼–⅓ cup
sweet, baked or boiled	½ large
Artichoke, French	1½ large
Beans, cooked, Corn, canned, Succotash — about	½ cup
Peas, canned, drained	¾ cup
Beets, Broccoli, Cauliflower, Carrots, Onions, Parsnips, Turnips, Squash, winter — about	1–1½ cups, cooked (about ½ lb.)
Squash, summer, Eggplant, Spinach, chard, kale, or cabbage, Tomatoes, canned — about	2–2½ cups, cooked
Tomatoes, fresh	2–3 large or 4 medium
Cabbage, raw, shredded	3½–4 cups
Cauliflower	Small head, 4½ in. diam.
Asparagus	20 large or 40 small stalks
Celery	20 stalks or hearts
Cucumbers	6 medium
Radishes	50 red, button
Lettuce	2 large, firm heads (Iceberg)
Salads:	
Greens, with French dressing	1–2 servings (depending on amount of dressing)
Vegetable or fruit, Fr. dressing	⅔ serving
Avg. salad, with mayonnaise dressing	½ serving
Dried fruit and nut salad, mayonnaise	¼ serving
Mayonnaise dressing	1 tbsp.
French dressing	1½ tbsp.
Sauces:	
Gravy, brown, med. thick	½ cup
White sauce, thin	⅓ cup
thick	¼ cup
Cheese sauce	¼ cup
Tomato sauce	5 tbsp.

Food.	Size of 100-calorie portion.
Hard sauce, Chocolate sauce, Tartar sauce, Hollandaise sauce	1 heaping tbsp.

Soups:

Bouillon or consommé	4 cups
Chicken, vegetable, or thin legume	1 cup
Cream or thick legume soups	½ cup (scant)

ALCOHOLIC BEVERAGES

Caloric Values of Usual Portions

	Portion.	Quantity.	Alcohol.	Calories.
Distilled Liquors:			Per cent By weight	
Liqueurs:				
Benedictine	Cordial Glass	20 c.c.	42	88
Brandy	" "	20 "	45	65
Chartreuse	" "	20 "	35	78
Curacao	" "	20 "	42	82
Crème de Menthe	" "	20 "	36	74
Gin		50 "	30	116
Rum		50 "	43	153
Rum, pure Jamaica		50 "	70	245
Whiskey, American		50 "	43	152
Whiskey, European		50 "	39	137
Wines, American:				
California, red	Claret Glass	120 c.c.	9.5	95
California, white	" "	120 "	9	89
Champagne	Champagne Glass	135 "	8	132
Port	Wine Glass	90 "	15	160
Sherry	" "	90 "	14.6	115
Wines, European:				
Champagne, dry	Champagne Glass	135 "	10	83
Champagne, sweet	" "	135 "	9.5	119
French, red (claret)	Claret Glass	120 "	8	81
French, white	" "	120 "	9	95
Madeira (sweet)	Wine Glass	90 "	15	107
Port	" "	90 "	16.7	135
Sherry	" "	90 "	17.4	125
Malt Liquors (American):				
Ale	Glass	250 "	6	155
Beer, lager, bottled	"	250 "	4.5	130
Beer, lager, draft	"	250 "	4.3	120
Porter	"	250 "	4.4	140
Mixed Drinks, Cocktails:				
(Rough approximates)				
Alexander	Cocktail Glass	75 "		225
Bronx	" "			235
Daiquiri	" "			125
Manhattan	" "			175
Martini, dry	" "			135
Mint julep				200
Old fashioned				105
Tom Collins				135

TABLE OF AVERAGE HEIGHTS AND WEIGHTS—MEN[1]

Age.	5 feet, 0 inch.	5 feet, 1 inch.	5 feet, 2 inches.	5 feet, 3 inches.	5 feet, 4 inches.	5 feet, 5 inches.	5 feet, 6 inches.	5 feet, 7 inches.	5 feet, 8 inches.	5 feet, 9 inches.	5 feet, 10 inches	5 feet, 11 inches	6 feet, 0 inch.	6 feet, 1 inch	6 feet, 2 inches.	6 feet, 3 inches.	6 feet, 4 inches.	6 feet, 5 inches.
15.....	107	109	112	115	118	122	126	130	134	138	142	147	152	157	162	167	172	177
20.....	117	119	122	125	128	132	136	140	144	148	152	156	161	166	171	176	181	186
25.....	122	124	126	129	133	137	141	145	149	153	157	162	167	173	179	184	189	194
*30.....	**126**	**128**	**130**	**133**	**136**	**140**	**144**	**148**	**152**	**156**	**161**	**166**	**172**	**178**	**184**	**190**	**196**	**201**
35.....	128	130	132	135	138	142	146	150	155	160	165	170	176	182	189	195	201	207
40.....	131	133	135	138	141	145	149	153	158	163	168	174	180	186	193	200	206	212
45.....	133	135	137	140	143	147	151	155	160	165	170	176	182	188	195	202	209	215
50.....	134	136	138	141	144	148	152	156	161	166	171	177	183	190	197	204	211	217
55.....	135	137	139	142	145	149	153	158	163	168	173	178	184	191	198	205	212	219

Height and weight taken with shoes on and coat off.
Subtract one inch from height measured with shoes on.
[1] From *How to Make The Periodic Health Examination* by Dr. E. L. Fisk and Dr. J. R. Crawford. The Macmillan Company.
* Weight at 30 years is put in bold-face type, since it represents the ideal weight to keep in later years for the sake of health.

TABLE OF AVERAGE HEIGHTS AND WEIGHTS—WOMEN[1]

Age.	4 feet, 8 inches.	4 feet, 9 inches.	4 feet, 10 inches.	4 feet, 11 inches.	5 feet, 0 inch.	5 feet, 1 inch.	5 feet, 2 inches.	5 feet, 3 inches.	5 feet, 4 inches.	5 feet, 5 inches.	5 feet, 6 inches.	5 feet, 7 inches.	5 feet, 8 inches.	5 feet, 9 inches.	5 feet, 10 inches	5 feet, 11 inches.	6 feet, 0 inch.
15.....	101	103	105	106	107	109	112	115	118	122	126	130	134	138	142	147	152
20.....	106	108	110	112	114	116	119	122	125	128	132	136	140	143	147	151	156
25.....	109	111	113	115	117	119	121	124	128	131	135	139	143	147	151	154	158
*30.....	**112**	**114**	**116**	**118**	**120**	**122**	**124**	**127**	**131**	**134**	**138**	**142**	**146**	**150**	**154**	**157**	**161**
35.....	115	117	119	121	123	125	127	130	134	138	142	146	150	154	157	160	163
40.....	119	121	123	125	127	129	132	135	138	142	146	150	154	158	161	164	167
45.....	122	124	126	128	130	132	135	138	141	145	149	153	157	161	164	168	171
50.....	125	127	129	131	133	135	138	141	144	148	152	156	161	165	169	173	176
55.....	125	127	129	131	133	135	138	141	144	148	153	158	163	167	171	174	177

Height and weight taken with shoes on and coat off
Subtract one inch from height measured with shoes on.
[1] From *How to Make The Periodic Health Examination* by Dr. E. L. Fisk and Dr. J. R. Crawford. The Macmillan Company.
* Weight at 30 years is put in bold-face type, since it represents the ideal weight to keep in later years for the sake of health.

WEIGHT—HEIGHT—AGE TABLE FOR BOYS FROM BIRTH TO SCHOOL AGE[1]

Height, inches.	Average weight, pounds.	Age.											
		1 mo.	3 mo.	6 mo.	9 mo.	1 yr.	1½ yrs.	2 yrs.	2½ yrs.	3 yrs.	4 yrs.	5 yrs.	6 yrs.
20	8	8											
21	9½	9	10										
22	10½	10	11										
23	12	11	12	13									
24	13½	12	13	14									
25	15	13	14	15	16								
26	16½	..	15	17	17	18							
27	18	..	16	18	18	19							
28	19½	..	..	19	19	20	20						
29	20½	..	..	20	21	21	21						
30	22	..	..	22	22	22	22	22					
31	23	..	..	..	23	23	23	23	24				
32	24½	..	..	..	24	24	24	25	25				
33	26	..	..	..	..	26	26	26	26	26			
34	27	..	..	..	..	..	27	27	27	27			
35	29½	..	..	..	..	..	29	29	29	29	29		
36	31	..	..	..	..	..	..	30	31	31	31		
37	32	..	..	..	..	..	..	32	32	32	32	32	
38	33½	..	..	..	..	..	..	..	33	33	33	34	
39	35	..	..	..	..	..	..	..	35	35	35	35	
40	36½	..	..	..	..	..	..	..	..	36	36	36	36
41	38	..	..	..	..	..	..	..	..	..	38	38	38
42	39½	..	..	..	..	..	..	..	..	..	39	39	39
43	41½	..	..	..	..	..	..	..	..	..	41	41	41
44	43½	..	..	..	..	..	..	..	..	..	..	43	43
45	45½	..	..	..	..	..	..	..	..	..	..	45	45
46	48	..	..	..	..	..	..	..	..	..	..	..	48
47	50	..	..	..	..	..	..	..	..	..	..	..	50
48	52½	..	..	..	..	..	..	..	..	..	..	..	52
49	55	..	..	..	..	..	..	..	..	..	..	..	55

Figures represent weight in pounds. Weights are net up to and including 34 inches height; above this with ordinary clothing but without shoes, coats or sweaters.
Weight to nearest pound.
Height to nearest inch.
Age to nearest birthday.

[1] Tables prepared by Robert M. Woodbury, Ph. D. and reprinted by permission of Children's Bureau, U. S. Dept. of Interior.

WEIGHT–HEIGHT–AGE TABLE FOR GIRLS FROM BIRTH TO SCHOOL AGE[1]

Height, inches.	Average weight, pounds.	Age.											
		1 mo.	3 mo.	6 mo.	9 mo.	1 yr.	1½ yrs.	2 yrs.	2½ yrs.	3 yrs.	4 yrs.	5 yrs.	6 yrs.
20	8	8											
21	9	9	10										
22	10½	10	11										
23	12	11	12	13									
24	13½	12	13	14	14								
25	15	13	14	15	15								
26	16½	..	15	16	17	17							
27	17½	..	16	17	18	18							
28	19	..	..	18	19	19	19						
29	20	..	..	19	20	20	20						
30	21½	..	..	21	21	21	21	21					
31	22½	..	..	..	22	22	23	23	23				
32	24	..	..	..	..	23	24	24	24	25			
33	25	..	..	..	..	..	25	25	25	26			
34	26½	..	..	..	..	..	26	26	26	27			
35	29	..	..	..	..	..	29	29	29	29	29		
36	30	..	..	..	..	..	..	30	30	30	30	31	
37	31½	..	..	..	..	..	..	31	31	31	31	32	
38	32½	..	..	..	..	..	..	..	33	33	33	33	
39	34	..	..	..	..	..	..	..	34	34	34	34	34
40	35½	..	..	..	..	..	..	..	..	35	36	36	36
41	37½	..	..	..	..	..	..	..	..	..	37	37	37
42	39	..	..	..	..	..	..	..	..	..	39	39	39
43	41	..	..	..	..	..	..	..	..	..	40	41	41
44	42½	..	..	..	..	..	..	..	..	..	..	42	42
45	45	..	..	..	..	..	..	..	..	..	..	..	45
46	47½	..	..	..	..	..	..	..	..	..	..	..	47
47	50	..	..	..	..	..	..	..	..	..	..	..	50
48	52½	..	..	..	..	..	..	..	..	..	..	..	52

Figures represent weight in pounds. Weights are net up to and including 34 inches height; above this with ordinary clothing but without shoes, coats or sweaters.
Weight to nearest pound.
Height to nearest inch.
Age to nearest birthday.

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WEIGHT—HEIGHT—AGE TABLE FOR BOYS OF SCHOOL AGE[1]

Height, inches.	Average weight for height, pounds.	5 years.	6 years.	7 years.	8 years.	9 years.	10 years	11 years.	12 years.	13 years.	14 years.	15 years.	16 years.	17 years.	18 years.	19 years.	Height, inches.
38	34	34	34*														38
39	35	35	35														39
40	36	36	36*														40
41	38	38	38	38*													41
42	39	39	39	39*	39*												42
43	41	41	41	41*	41*												43
44	44	44	44	44	44*												44
45	46	46	46	46	46*	46*											45
46	48	47*	48	48	48	48*											46
47	50	49*	50	50	50	50*	50*										47
48	53		52	53	53	53	53*										48
49	55		55	55	55	55	55	55*									49
50	58		57*	58	58	58	58	58*	58*								50
51	61			63	61	61	61	61	61*								51
52	64			64	64	64	64	64	64	64*							52
53	68			66*	67	67	67	67	68	68*							53
54	71				70	70	70	70	71	71	72*						54
55	74				72*	72	73	73	74	74	74*						55
56	78				75*	76	77	77	77	78	78	80*					56
57	82					79*	80	81	81	82	83	83*					57
58	85					83*	84	84	85	85	86	87					58
59	89						87	88	89	89	90	90	90				59

60	94						91*	92	92	93	94	95	96			60
61	99							95	96	97	99	100	103	106*		61
62	104							100*	101	102	103	104	107	111	116*	62
63	111							105*	106	107	108	110	113	118	123	127*	63
64	117								109	111	113	115	117	121	126	130*	64
65	123								114*	117	118	120	122	127	131	134	65
66	129									119	122	125	128	132	136	139	66
67	133									124*	128	130	134	136	139	142	67
68	139										134	134	137	141	143	147	68
69	144										137	139	143	146	149	152	69
70	147										143	144	145	148	151	155	70
71	152										148*	150	151	152	154	159	71
72	157											153	155	156	158	163	72
73	163											157*	160	162	164	167	73
74	169											160*	164	168	170	171	74

Age—Years		6	7	8	9	10	11	12	13	14	15	16	17	18	19
Average height (inches)	Short	43	45	47	49	51	53	54	56	58	60	62	64	65	65
	Medium	46	48	50	52	54	56	58	60	63	65	67	68	69	69
	Tall	49	51	53	55	57	59	61	64	67	70	72	72	73	73
Average annual gain (lbs.)	Short	3	4	5	5	5	4	8	9	11	14	13	7	3	
	Medium	4	5	6	6	6	7	9	11	15	11	8	4	3	
	Tall	5	7	7	7	7	8	12	16	11	9	7	3	4	

The figures represent weight in pounds; age, at nearest birthday; height at nearest inch; weight at nearest pound.

Starred figures are estimated weights for children who are taller or shorter than usual for the age group. All unstarred figures represent actual averages.

- Weight in ordinary clothing but without shoes, coats or sweaters.

† Tables prepared by Bird T. Baldwin, Ph.D., Iowa Child Welfare Research Sta., State Univ. of Iowa, and Thos. D. Wood, M.D., Columbia University. Reprinted by courtesy of the Am. Child Health Association.

WEIGHT–HEIGHT–AGE TABLE FOR GIRLS OF SCHOOL AGE[1]

Height, inches.	Average weight for height, pounds.	5 years.	6 years.	7 years.	8 years.	9 years.	10 years.	11 years.	12 years.	13 years.	14 years.	15 years.	16 years.	17 years.	18 years.	Height, inches.
38	33	33	33*													38
39	34	34	34													39
40	36	36	36	36*												40
41	37	37	37	37*												41
42	39	39	39	39–												42
43	41	41	41	41	41*											43
44	42	42	42	42	42*											44
45	45	45	45	45	45	45*										45
46	47	47*	47	47	48	48*										46
47	50	49*	50	50	50	50	50*									47
48	52		52	52	52	52	53*	53*								48
49	55		54	54	55	55	56	56*								49
50	58		56*	56	57	58	59	61	62*							50
51	61			59	60	61	61	63	65							51
52	64			63*	64	64	64	65	67							52
53	68			66*	67	67	68	68	69	71*						53
54	71				69	70	70	71	71	73*						54
55	75				72*	75	74	74	75	77	78*					55
56	79					76	78	78	79	81	83*					56
57	84					80*	82	82	82	84	88	92*				57
58	89						84	86	86	88	93	96*	101*			58
59	95						87	87	90	92	96	100	103*	104		59

60	101						91*	95	95	97	101	105	108	109	111*	60
61	108							99	100	101	105	108	112	113	116	61
62	114							104*	105	106	109	113	115	117	118	62
63	118								110	110	112	116	117	119	120	63
64	121								114*	115	117	119	120	122	123	64
65	125								118*	120	121	122	123	125	126	65
66	129									124	124	125	128	129	130	66
67	133									128*	130	131	133	133	135	67
68	138									131*	133	135	136	138	138	68
69	142										135*	137*	138*	140*	142*	69
70	144										136*	138*	140*	142*	144*	70
71	145										138*	140*	142*	144*	154*	71

Age—Years		6	7	8	9	10	11	12	13	14	15	16	17	18
Average height (inches)	Short	43	45	47	49	50	52	54	57	59	60	61	61	61
	Medium	45	47	50	52	54	56	58	60	62	63	64	64	64
	Tall	47	50	53	55	57	59	62	64	66	66	67	67	67
Average annual gain (lbs.)	Short	4	4	4	5	6	6	10	13	10	7	2	1	
	Medium	5	5	6	7	8	10	13	10	6	4	3	1	
	Tall	6	8	8	9	11	13	9	8	4	4	1	1	

The figures represent weight in pounds; age, at nearest birthday; height at nearest inch; weight at nearest pound.

Starred figures are estimated weights for children who are taller or shorter than usual for the age group. All unstarred figures represent actual averages.

Weight in ordinary clothing but without shoes, coats or sweaters.

Tables prepared by Bird T. Baldwin, Ph.D., Iowa Child Welfare Research Sta., State Univ. of Iowa, and Thos. D. Wood, M.D., Columbia University. Reprinted by courtesy of the Am. Child Health Association.

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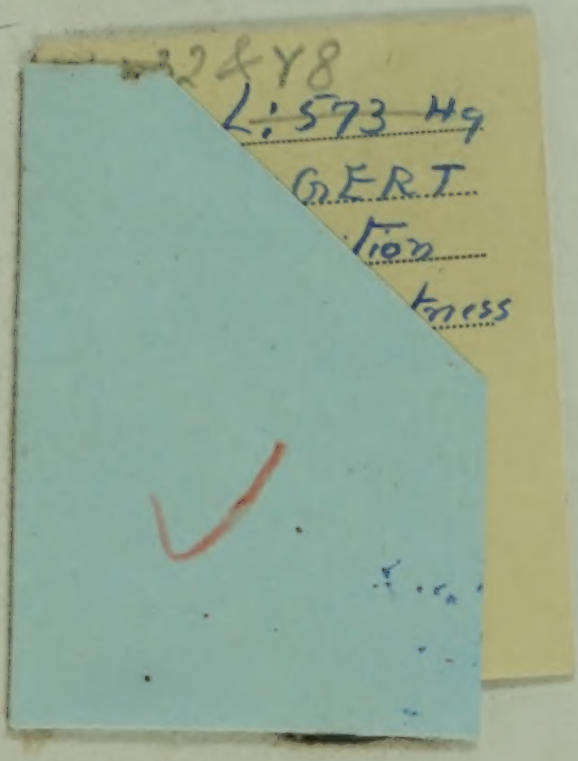
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